The Bioregions of New South Wales

their biodiversity, conservation and history

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Photo: J. Little

NSW National Parks and Wildlife Service

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List of acronyms and abbreviations

ACT	Australian Capital Territory
ANCA	Australian Nature Conservation Agency
CAMBA	China – Australia Migratory Bird Agreement
CAR	Comprehensive, Adequate and Representative
CRA	Comprehensive Regional Assessment
CSA mine	Cornish, Scottish and Australian mine
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIWA	Directory of Important Wetlands of Australia
DLWC	Department of Land and Water Conservation
DUAP	Department of Urban Affairs and Planning
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
EPA Act	Environmental Planning and Assessment Act (1979)
EPBC Act	Environmental Protection and Biodiversity Conservation Act (1999)
GIS	Geographic Information System
HO	Heritage Office
IBCA	Integrated Biodiversity Conservation Assessment
IBRA	Interim Biogeographic Regionalisation of Australia
JAMBA	Japan – Australia Migratory Bird Agreement
LEP	Local Environment Plan
NPW Act	National Parks and Wildlife Act (1974)
NPWS	National Parks and Wildlife Service
NSW	New South Wales
NVC Act	Native Vegetation Conservation Act (1997)
QLD (Qld)	Queensland
RACAC	Resource and Conservation Assessment Council
RACD	Resource and Conservation Division (Planning NSW)
RAOU	Royal Australasian Ornithologists Union
RVC	Regional Vegetation Committee
SA	South Australia
SCA	State Conservation Area
SCMP	State Conservation Monitoring Project
SEPP	State Environmental Planning Policy
SRA	State Recreation Area
TS Profile	Threatened Species Profile
TSC Act	Threatened Species Conservation Act (1995)
UNESCO	United Nations Educational, Scientific and Cultural Organisation
VCA	Voluntary Conservation Agreement
VIC (Vic)	Victoria
WR	Wildlife Refuge

Photo: G. Robertson

Introduction

1. Bioregional conservation and the NSW Biodiversity Strategy

This document provides a series of textual snapshots of the conservation character and significance of the 17 bioregions of NSW. Each chapter presents information on a variety of characteristics of the bioregion, including both physical descriptions and its conservation status.

This report is one of a series of documents which utilise a bioregional framework in the assessment of the terrestrial biodiversity of NSW. It was prepared as part of a suite of projects which were funded under the NSW Biodiversity Strategy and were designed to fill gaps in information and to provide tools for State and bioregional conservation assessment. A diagram showing the relationships between these projects is given in Appendix 1.

The broad aim of the Bioregional Overviews project and associated NSW Biodiversity Strategy projects under the Integrated Bioregional Conservation Assessment (IBCA) package (see Appendix 1 for IBCA projects funded under the NSW Biodiversity Strategy) is to use an integrated, whole-of-government approach in collating and distributing biodiversity data and information in order to adequately assess the conservation significance of land throughout NSW (NSW NPWS 1999a).

This document has been prepared for a diverse readership ranging from high school students to local, State and Federal Governments, as well as industry, including tourism and agriculture, and as an initial source for those preparing more detailed regional conservation assessments and planning. The document offers a description of the unique character of each of the bioregions, and shows how important it is to understand the significance of biogeographic regions (bioregions) in conservation planning. In doing this, we hope to provide a greater understanding of how we describe conservation values and of the challenges ahead for conservation and land management.

1.1 What is a bioregion?

Following the trend of governments throughout Australia, the NSW National Parks and Wildlife Service has adopted a bioregional approach to conserving much of our biodiversity in response to the need to work with large geographic scales and biological cycles to plan and achieve biodiversity conservation.

Bioregions are relatively large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems. They capture the large-scale geophysical patterns across Australia. These patterns in the landscape are linked to fauna and flora assemblages and processes at the ecosystem scale, thus providing a useful means for simplifying and reporting on more complex patterns of biodiversity.

Planning for biodiversity at this scale recognises the significance of these natural processes and gives us the greatest opportunity to conserve biodiversity in sufficient numbers and distribution to maximise its chance of long-term survival.

Biodiversity is influenced by but does not recognise administrative boundaries, which is another reason to use a bioregional approach to assess all land across the region.

Subregions, as described by Morgan and Terrey (1992), are "based on finer differences in geology, vegetation and other biophysical attributes and are the basis for determining the major regional ecosystems". The subregions that make up each of the bioregions are useful tools in regional conservation planning and in the development of a conservation reserve system that, if it is to be representative of the natural environment, "must contain viable areas of the major ecosystems of each natural region" (Morgan and Terrey 1992).

2. The bioregional and subregional framework

It became apparent in the early 1990s that administrative regions were no longer a satisfactory basis for conservation assessment and planning (Dick 2000). Consequently, the mapping of the bioregions of Australia was undertaken by the Federal Government in cooperation with State and territory conservation agencies to provide a consistent and robust framework for biodiversity assessment and planning.

The result of this Australia-wide mapping exercise was the production of the Interim Biogeographic Regionalisation of Australia or IBRA (Thackway and Cresswell 1995), a system that divides Australia into bioregions on the basis of their dominant landscape-scale attributes. IBRA was developed as a framework primarily to identify deficiencies in the Australian network of protected areas and to set priorities for further enhancing the reserve system (Thackway and Cresswell 1995). The term "interim" is retained in the IBRA title because the bioregions are periodically updated as new or more reliable information comes to hand from a range of biological and environmental surveys (Environment Australia 2000) designed to refine bioregional boundaries. At the time of writing, IBRA Version 5.1 contained the most recent updates.

Across Australia some 130 biogeographic regions had already been identified but there had been little communication or congruency across State and territory boundaries about these regions. The use of datasets and environmental information including climate, lithology, geology, landform, vegetation, flora and fauna, land use and other attributes provided the means of rationalising these 130 regions into 80 biogeographic regions, which were then further refined into the 85 bioregions recognised in Australia today (Thackway and Cresswell 1995, Environment Australia 2000). Of these 85 bioregions, 17 are found in NSW. Two lie wholly within the NSW boundary, while the other 15 are shared with bordering States – Victoria, South Australia and Queensland.

The description of IBRA regions according to their geography and ecology (NSW NPWS 1999a) are, however, more relevant to environmental management than administrative boundaries (such as State borders), which are unrelated to the physical attributes of the Australian landscape. The IBRA bioregions therefore provide a logical and functional framework for conservation management, land use and planning throughout Australia.

Throughout Australia bioregions have been further divided into subregions or provinces. Subregions are based on finer differences in biophysical attributes including geology and vegetation (Morgan and Terrey 1992) and because they provide more detailed information about the landscape they can be used for finer scale planning. Just as the bioregions vary in size, with larger regions, mainly those in arid or semi-arid climates, reflecting less

diverse terrain (Thackway and Cresswell 1995), the size, and therefore the number, of subregions found in each bioregion also varies.

To make decisions about biodiversity we need to understand where species occur, the habitats they occur in and the ecological processes that drive those habitats and larger groupings of communities. Bioregional assessments have occurred only over the last 6 years in NSW, and our bioregional information base is variable but dynamic. Information on biodiversity has been, and will continue to be, gathered at many levels of detail as part of bioregional or statewide assessments or will emerge as a result of more detailed management of individual areas, ecosystems or species.

We can begin to describe and report on the condition of biodiversity in the NSW bioregions although not always as precisely as is needed for detailed land management decisions. This document provides some of the more detailed information on biodiversity for each bioregion at the same time as using less detailed data sets to enable comparisons between bioregions.

3. Aims and objectives of the Bioregional Overviews project

This document aims to provide a series of textual snapshots of the conservation character and significance of the 17 bioregions of NSW. The information collated for the project includes the physical attributes of the landscape and the human links to the environment, as well as the biodiversity and conservation values of each bioregion. The need for the publication of this document is based on the acceptance that it will be some time before the detailed information about the bioregions flowing from other IBCA projects and specific bioregional assessments becomes available.

Land managers and conservation planners need to know what is present in the landscape, where it is and what condition it is in. This information must be known at four scales:

- statewide;
- bioregional;
- ecosystem; and
- species.

The Bioregional Overviews project provides a basis for establishing conservation priorities by offering guidance to conservation planners on setting such priorities at a coarse, bioregional scale.

It is anticipated that this report, *The Bioregions of New South Wales: their biodiversity, conservation and history*, will be periodically updated to incorporate new data when it becomes available. Where no bioregional assessments exist for a bioregion, the bioregional overview will provide an interim, coarse-scale description of the environment and past and present land management to guide decision-making in the bioregion. Data from regions where bioregional assessments are under way can be used to prepare a more comprehensive overview. Where there is a need to examine the inevitable differences arising out of separate regional or bioregional planning processes in adjacent bioregions, this document may provide a basis for doing so. The document will also highlight where bioregional-scale information and data is currently lacking.

4. How to use this document

Each chapter describes one of the 17 NSW bioregions with maps and references relating to that bioregion presented in that particular chapter. The order of the chapters proceeds from a description of the north-western bioregions to those in the south-east of NSW.

Each chapter is divided into the following sections.

4.1 Location

The location section describes the geographical position and area of the bioregion in NSW with reference to:

- major towns and roads;
- major rivers and catchments; and
- shared boundaries with neighbouring States.

4.2 Climate

Details of the climate of each bioregion has been sourced from the Australian Bureau of Meteorology (see References at the end of this chapter for website address). The short description of the broad climatic characteristics of each bioregion provided in each chapter is based on the *Objective Classification of Australian Climates* (Stern *et al.* 2000).

Also provided are figures for the climate variables as shown in Table 1 below.

4.3 Topography

The topography section describes the characteristic landscape features, or shape of the landscape of the bioregion.

4.4 Geology and geomorphology

The geology and geomorphology section describes the dominant underlying geology or rock types for each bioregion as well as the major geomorphic events leading to the development of the landscape we see today.

Because geomorphic events are generally at a larger scale than the bioregional level, it is important to get a sense of the geomorphic landscape of each bioregion in a state-wide or even continental context. For this reason, an outline of the major events which led to the formation of the major landscape features of NSW is provided in Chapter 1 "A brief overview of New South Wales".

4.5 Geodiversity

The geodiversity section gives a brief overview of the main features of geological and/or geomorphic interest in each bioregion.

4.6 Soils

The soils section describes the main soil types found in the bioregion, the geology from which they are derived and that part of the landscape in which they are usually found.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall

Table 1. Climate variable information provided for each bioregion (derived from the Australian National University – Centre for Resource and Environmental Studies ANUCLIM 5.1 software package of programs that enable the user to obtain estimates of monthly climate variables)

Photo: J. Little

4.7 Biodiversity

The biodiversity section is divided into the following subheadings:

- Plant communities
  This section describes the major plant communities found in the bioregion.
- Significant flora
  This section describes significant flora, particularly those listed in the schedules of the NSW *Threatened Species Conservation* (TSC) *Act (1995)* and the Commonwealth *Environmental Protection and Biodiversity Conservation* (EPBC) *Act (1999)*, including endangered ecological communities and endangered and vulnerable populations and species.
- Significant fauna
  This section describes significant fauna found in the bioregion, in particular species or populations listed in the schedules of the *TSC Act (1995)* and *EPBC Act (1999)*.
- Significant wetlands
  Wetlands are better defined by catchment boundaries than by bioregional boundaries. None the less, information on the wetlands of each bioregion has been included for those interested in planning or working at the bioregional scale. New information gathered as part of the Australian Terrestrial Biodiversity Assessment (2002) is included in this section.

Invertebrates have not been extensively surveyed across NSW or generally across Australia and therefore little is known about them in comparison to the number of invertebrate species predicted to occur. There is invertebrate information available for some bioregions, however it has not been included here as surveys had not been completed at the time of writing.

4.8 Regional history

The regional history section describes the interaction between humans and the bioregional landscape as well as the cultural significance of the bioregional landscapes and the influence humans have had on bioregional biodiversity.

The regional history section of each chapter is divided into two parts:

- Aboriginal occupation
  This section includes the main Aboriginal language groups that occupy the bioregion or have historically lived in that bioregion. There is much overlap between areas inhabited or visited by the different language groups in the Western Division, and for this reason a summary of the Aboriginal occupation of the Western Division is provided separately in Chapter 1 "A brief overview of New South Wales". Under the heading "Aboriginal occupation" in the chapters on bioregions located in western NSW, the reader will be prompted to return to this section in Chapter 1 to read about the Aboriginal heritage of that bioregion.
- European occupation
  This section provides a brief account of early exploration and European settlement, major historic events and development of the main towns in a particular bioregion and their socio-economic basis. An account of European heritage in the Western Division bioregions is provided separately in Chapter 1 "A brief overview of New South Wales" and the reader will be prompted in this section in the chapters on western NSW bioregions to return to Chapter 1 to read about the European history of that bioregion.

4.9 Bioregional-scale conservation

The goals of the NSW National Parks and Nature Reserve system are to protect comprehensive, adequate and representative samples of all natural landscapes in the system. That is, they aim to protect the full variety of ecosystems with sufficient size and condition to remain viable for hundreds of years. However, to achieve truly adequate protection of ecosystems so that they sustain natural processes well into the distant future, there is a need to focus on complementary conservation of landscapes outside the National Parks and Nature Reserve system.

A range of conservation mechanisms are available to achieve conservation in NSW and are outlined in Appendix 2. The role of these mechanisms in the conservation of landscapes has been reviewed to provide a simple (but until now never undertaken) comparison of conservation and conservation-oriented land management mechanisms in and across bioregions. A review of the conservation mechanisms available in each bioregion is documented in this section of every chapter.

It should be noted that only mechanisms with a state-wide legislative basis were surveyed. Of the range of legislatively based conservation mechanisms, only those with state-wide data available at the time of writing were analysed. It should also be noted that a new category of reserve that has been recognised in legislation, the State Conservation Area, was not analysed as none had been gazetted at the time of analysis.

4.10 Subregions

Although the aim of this document is to provide a general overview of the bioregions of NSW, we have included a description, based on the work of Morgan and Terrey (1992) and Morgan (2001), of the finer-scale subregions that make up each bioregion.

5. Data and analysis

The data used to describe the conservation status of each bioregion were provided from analysis undertaken by the State Conservation Monitoring Project (SCMP). Not all conservation mechanisms analysed are mutually exclusive, and there is some overlap. This means that figures cannot simply be aggregated to provide accurate protected area totals for all programs. While areas and percentages for the majority of mechanisms are generally not accurate to two decimal places, we have included data to this level of accuracy to show the contribution made by small but important initiatives such as Wildlife Refuges, Voluntary Conservation Agreements and Property Agreements.

The area of each bioregion has been derived from IBRA version 5.1 and analysed. These areas may not perfectly match the areas of the bioregions calculated from the SCMP because of variations in grid size. 1km grid cells were used in the SCMP to calculate the area of landscapes and both vegetated and cleared areas of the bioregion.

The NSW Listing of Ecosystems was developed by the Conservation Assessment and Priorities Unit of the NPWS and Groundtruth Consulting as part of the NSW Biodiversity Strategy. The conservation status of the western bioregions was derived using the mapped landscape units resulting from the NSW Listing of Ecosystems project. At the time of analysis, this landscape mapping (Mitchell in prep) was not complete for the east of the State, so an alternative landscape classification (NPWS in prep) was used as the basis for the statistics for the eastern bioregions. Further details on data sets and analysis can be obtained from the State Conservation Monitoring Project (NPWS in prep).

Chapters describing the western NSW bioregions (with conservation status statistics based on Mitchell (in prep) landscape mapping) are placed close together in this report and eastern NSW bioregions are located together (with conservation status statistics based on NPWS (in prep) landscapes classification). A map of the location of protected areas in each bioregion is contained in the chapter for that bioregion. It should be noted that these maps do not indicate the locations of Voluntary Conservation Agreements, Wildlife Refuges or Property Agreements in order to protect the privacy of the landholders involved.

Finally, figures provided in the conservation status section of each chapter apply to the NSW portion of the bioregions only. As the majority of bioregions in NSW extend across the borders of adjoining States, the data provided is insufficient to give a complete picture of the bioregions for the purposes of bioregional planning across State administrative boundaries.

We hope in the future to be able to incorporate a more complete and comprehensive analysis of the whole of each bioregion.

6. Maps

There are six maps provided for each bioregional chapter. These are:

- Location map showing the main towns and roads;
- Topographic map;
- Rivers map showing other main water bodies and Catchment Management Board Areas;
- Vegetation map showing areas with vegetation cover and areas cleared in the bioregion;
- Protected Areas map showing areas managed under different conservation mechanisms such as National Parks and Nature Reserves; and
- Map of subregions and landscapes of each bioregion.

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CHAPTER 1

A brief overview of New South Wales

1. The bioregional landscape of NSW

The diversity of NSW landscapes is evident in the wide range of the State's bioregions. Those bioregions in western NSW represent sandy deserts (Simpson Strzelecki Dunefields, Channel Country, Murray Darling Depression), riverine plains (Riverina, Darling Riverine Plains), rocky ranges (Mulga Lands, Broken Hill Complex) and rolling downs (Cobar Peneplain). Towards the east of the State there are lush rainforests (NSW North Coast, South East Corner), rugged mountains (Sydney Basin, New England Tableland, Australian Alps, South Eastern Highlands), undulating ranges (Brigalow Belt South, Nandewar) and fragile, wooded grasslands (NSW South Western Slopes).

The 17 bioregions found in NSW vary considerably in the types of natural values they contain, and although they all have some representation in protected areas, there is great variation in the extent of each reserved. The bioregion with the highest proportion reserved is the Australian Alps Bioregion, with almost 90% protected. The reason for this high proportion is the prevalence of the alpine environs of Kosciuszko National Park, which dominate this bioregion. This provides a major contrast to bioregions such as the Riverina and Darling Riverine Plains Bioregions, where less than 1% of each lie within protected areas.

2. Location

NSW has a total area of 80,160,000 hectares (801,600 square kilometres). The Macintyre and Dumaresq Rivers form part of the State boundary with Qld, while the Murray River forms part of the southern NSW-Victorian boundary. Seventeen of the 85 Australian bioregions are represented in NSW, but only 2 of these 17 bioregions lie wholly within the NSW boundary, while the other 15 are shared with the bordering States: Victoria, South Australia and Queensland. An outline of the NSW bioregions, their total areas and the States they occupy are shown in Table 2. The bioregion with the largest area in NSW is the Darling Riverine Plains Bioregion.

3. Climate

NSW is described as being in the temperate zone although the climate undergoes large variations depending on proximity to the coast and mountains (EPA 1997). The temperature can be very high in the north-west of the State and very cold in the southern alpine regions, but the climate across NSW is generally mild. Long-term median rainfall varies from a low of 200 mm in the arid north-west of the State to a high of more than 1,500 mm along the north-east coast (EPA 1997). This describes a general trend, with rainfall decreasing from the east to the west of NSW.

IBRA Bioregion	Australian States and Territories	Total NSW area (ha)	% of bioregion in NSW
Australian Alps	NSW, ACT, VIC	428,760	54.07
Brigalow Belt South	NSW, QLD	5,338,619	19.83
Broken Hill Complex	NSW, SA	3,819,374	66.97
Channel Country	NSW, QLD, SA	1,428,032	5.01
Cobar Peneplain	NSW	7,350,084	100.00
Darling Riverine Plains	NSW, QLD	9,398,531	88.23
Mulga Lands	NSW, QLD	6,553,109	25.90
Murray Darling Depression	NSW, SA, VIC	8,046,458	40.74
Nandewar	NSW, QLD	2,070,128	76.71
New England Tablelands	NSW, QLD	2,861,145	95.24
North Coast	NSW, QLD	5,694,360	96.11
South Western Slopes	NSW, VIC	8,087,580	93.24
Riverina	NSW, VIC	7,102,727	74.07
Simpson Strzelecki Dunefields	NSW, QLD, SA	2,116,501	7.19
South East Corner	NSW, VIC	1,300,742	48.15
South Eastern Highlands	NSW, ACT, VIC	4,894,488	55.98
Sydney Basin	NSW	3,632,890	100.00

Table 2. NSW bioregions and proportion of each in NSW (Based on figures from IBRA Version 5.1 adapted from Thackway and Cresswell 1995, Environment Australia 2000.)

4. Topography and geomorphology

Topography, geomorphology and geomorphic history are usually linked to large, sometimes continental-scale, events. For this reason, the following summary of the major events in the formation of the landscape of NSW has been provided.

Gondwana

"The land masses of the world were once aggregated into a single supercontinent called Pangea. Eventually Pangea separated into two parts, Laurasia to the north and Gondwana to the south. Gondwana comprised South America, Africa, Madagascar, Antarctica, Australia and New Zealand and some now northern lands including India, Turkey and Arabia. Gondwana started to break up into smaller continents about 180 million years ago. Fifty million years ago Australia broke away from Antarctica, severing its last links with the other great lands of Gondwana." (White 1986)

Major events in the formation of the landscape in NSW

NSW contains three main topographical divisions, as follows:

1. The Great Dividing Range comprising the Eastern Highlands, the Great Escarpment and the Western Slopes
2. The Far West Uplands
3. The Western Plains lying in between.

The eastern half of the State comprises thick sequences of sedimentary and metamorphic rocks that were intruded by granites and folded and faulted while the continent was part of Gondwana. Thick piles of less deformed sediments accumulated in the Murray, Sydney and Great Artesian Basins. Subsequently the whole east coast and Great Dividing Range was created by earth movement warping up a gentle arch along the eastern edge of the continent. This was associated with the opening of the Tasman Sea and Southern Ocean during the break-up of Gondwana.

This break-up was accompanied by volcanic activity in some places, and the short steep rivers flowing to the Pacific rapidly eroded the eastern slopes to produce the steep and rugged escarpments and deep gorges that run behind the coast. Geomorphically, the western slopes can be seen as a dissected ramp that links the uplifted highlands with the western plains. The Great Dividing Range is an elevated region of gently undulating country or broad plains, with the exception of areas of dramatic gorge country associated with the Great Escarpment (Packham 1969).

The Western Plains are vast areas of shallow riverine sediment deposited by streams ancestral to the Murray-Murrumbidgee in the Riverina and the Darling and its tributaries in the Darling Riverine Plain. The plains slope gently west from the Great Dividing Range and lie against the eroded bedrock plateau and low ranges of the Cobar Block and the Barrier Ranges. The extensive sand sheets and dunefields of the Murray Basin cover bedrock in the south-western corner of the State.

The Western Plains experienced very little total uplift, but here and there in the Far West Uplands there has been some post-Miocene faulting.

5. Biodiversity

The definition of "biodiversity" adopted by the NSW Biodiversity Strategy is:

> *The variety of life forms, the different plants, animals and microorganisms, the genes they contain, and the ecosystems they form. It is usually considered at three levels: genetic diversity, species diversity and ecosystem diversity.*

Simply, biodiversity can be described as life's variety (NSW NPWS 1999a).

Australia's native biodiversity is significant at a global scale (NSW NPWS 1999a) and it is estimated that Australia supports more than one million species of plants and animals. As well as a high number of species, Australia, and even NSW alone, also supports a great number and diversity of natural environments from the mountains to the coast, to woodlands, grasslands, rainforests and deserts (NSW NPWS 1999a).

Knowledge of terrestrial biodiversity across NSW varies according to the research effort put into a particular area. To enable comparison across bioregions, the datasets used were generally consistent across the State and for this reason may not have been the most sophisticated available for each region. This has led to a focus on elements of biodiversity such as threatened fauna and flora, which is but one way of describing biodiversity, and other information needs to be considered to gain a better overall picture of the status of biodiversity and its management across a bioregion.

The rich biodiversity contained in a variety of NSW landscapes cannot be taken for grated, and more than 700 species of plants and animals are listed as threatened in NSW under Schedules 1 and 2 of the *Threatened Species Conservation Act, 1995* (TSC Act) (NSW NPWS 1999b). The conservation of these species is crucial in maintaining biodiversity, yet the list of threatened species continues to grow. In NSW, more than 40 fauna and 40 flora species are presumed extinct; more that 40 fauna and 210 flora species are endangered; and more than 160 fauna and 190 flora species are vulnerable (NSW NPWS 1999b).

Of the species listed as endangered or vulnerable in the TSC Act, four reptiles, seven birds, six mammals and almost 300 plants are also listed in the Commonwealth *Environment Protection and Biodiversity Conservation Act*, 1999 as threatened nationally.

An endangered ecological community is an assemblage of native species that is likely to become extinct in NSW if threats continue (EPA 1997). At the time of writing, there were 28 ecological communities listed as endangered in NSW on the schedules of the TSC Act. The Sydney Basin Bioregion, for example, contains several of the State's endangered ecological communities. The majority of endangered ecological communities are listed because they are highly fragmented and hence their long-term viability is threatened (EPA 1997).

6. Regional history

6.1 Aboriginal occupation

Aborigines have lived in the area known as NSW for at least 45,000 years and traditionally there are more than 38 Aboriginal language groups. The Aboriginal heritage of each bioregion is described in the chapter for that bioregion, except for those bioregions in the Western Division of NSW where the overlap of language groups required a broad description as provided in the following account by way of background information.

Aboriginal Occupation of the Western Division

(This section is largely based on HO and DUAP 1996: Chapter 16 of *Regional Histories of New South Wales*.)

The NSW Western Division, effectively bisected by the Darling River, was traditionally home to around 15 major Aboriginal groups. Many of these groups lived along the rivers of the Western Division, the Barwon, Darling, Lachlan, Murray, Paroo and Warrego Rivers, which provided Aboriginal people with more reliable and plentiful food supplies than those people living away from the major rivers in the scrub country and mallee (HO and DUAP 1996).

The Wiradjuri language group, whose homeland was traditionally centred on the area south of Cobar on the Lachlan River, reached their westernmost extent along the Lachlan through the Riverina Bioregion to the junction of the Lachlan and Murrumbidgee Rivers. Adjacent to this homeland in the north-west of the Riverina Bioregion and south-east of the Murray Darling Depression were the traditional lands of the Jitajita. The Kureinui people lived along the northern bank of the Murray and west to where the Darling joins, while further west were the traditional lands of the Maraura. The Maraura hunted over the border in the South Australian mallee each winter (HO and DUAP 1996) and were also known as Wiimbaio (Berndt and Berndt 1964). The Barkindji people were predominant around the lower Darling, which they called the Barka, Barkindji literally meaning "Darling folk". The homelands of the Barkindji extended from what is now Wentworth in the Riverina Bioregion, northward through the Murray Darling Depression Bioregion and into the Darling Riverine Plains Bioregion beyond Wilcannia (HO and DUAP 1996). Barkindji homelands were known to extend into Queensland via the Paroo due to the friendly relations they had with the Parundji people of the Darling Riverine Plains Bioregion (HO and DUAP 1996). The home of the Parundji was the banks of the Paroo River, although unlike the Murray and Darling River groups, they did not use the rivers for transport in bark canoes.

The mid-Darling was traditionally occupied by the Naualko people on the west bank near the Warrego junction in the Mulga Lands Bioregion. Further upstream near Bourke and Brewarrina, the Ngemba people occupied the east bank of the Darling in the Darling Riverine Plains, while the Baranbinja and Ualarai people lived on the west bank of the Darling in the Mulga Lands Bioregion (HO and DUAP 1996). The Darling River was a less reliable water source than the Murray and because of this the use of fishing equipment is more elaborate. The fish-traps built by the Ngemba in the river near Brewarrina provide a good example of the innovations by the local Aboriginal people in water management, as does the stone dam built by Aborigines just downstream of the Darling-Warrego River junction (HO and DUAP 1996).

Other Aboriginal groups of the Western Division were not wholly reliant on the rivers, accessing them only in times of drought or extreme heat. From the Lachlan to the east bank of the Darling River was the homeland of the Barindji (not Barkindji) and the Wongaibon, and to the west in the corner country were further groups.

The Karenggapa people traditionally occupied the far north-west corner of NSW in the Channel Country Bioregion at the Queensland border (HO and DUAP 1996). The Maliangapa people occupied the area around the seasonal lakes south of Tibooburra and, like the Karenggapa, were more likely to travel north or west rather than join the people of the Murray-Darling on the rivers (HO and DUAP 1996). However, further south in the Broken Hill Complex Bioregion the Wiljakali people traditionally occupied the lands around Broken Hill (HO and DUAP 1996) and visited the Barkindji people on the Menindee Lakes in the Darling Riverine Plains Bioregion each year.

Just as the majority of Aboriginal groups populated the areas close to water, early European settlement in the west began with the rivers, and so it was the Aboriginal people of the far west and mallee regions who survived the longest with little European disturbance. The Barindji people east of Menindee are one example, living their traditional lives into the 1850s without interruption. The river groups such as the Barkindji were much less fortunate, losing their traditional lands and hence their existence as hunters and fishers as early as the 1830s. Although the Barkindji resisted European attempts to invade their country – and were, for a while, successful, they were soon to lose their rightful place in the landscape (HO and DUAP 1996).

Once European settlement was well under way in the west, Aborigines on the Murray River began working on stations and were often responsible for the transportation of wool bales in their bark canoes along the rivers south to the Victorian markets (HO and DUAP 1996).

The riverboat trade began on the Murray and Darling Rivers around 1853, at which time the lifestyles of the river people were disturbed irreversibly. Aboriginal people were then employed as timber cutters, the timber used as fuel to power the steamers' boilers. When a steamboat, the "Gemini", made its maiden voyage on the upper Darling in 1859, it soon encountered the Ngemba fish-traps at Brewarrina, which stopped its progress – but not for long. The traps were dismantled in part and by the 1870s, with the right water levels, steamboats could reach as far upstream as Walgett in the Darling Riverine Plains Bioregion.

Aboriginal men of the west were also employed as shearers and cattlemen on many of the stations during the 1860s and 1870s, while Aboriginal women were employed as domestic helpers in homesteads, sometimes bearing settlers' children (HO and DUAP 1996).

By this time – the 1870s – only the Aboriginal people of the most arid areas retained, for the most part, their traditional lifestyles. However, traditional lifestyles required mobility over large areas of the landscape to use the products which the Aborigines needed to subsist. The European presence did not allow this mobility and the range of the Aborigines was restricted to such an extent that there was no choice for them but to relinquish their traditional ways and turn to missions and stations simply in order to exist (HO and DUAP 1996).

The struggles of station owners from the 1890s due to droughts and harsh conditions on the land also adversely affected the Aboriginal tribal groups of the west and as a result their populations rapidly declined. As they left the stations, Aboriginal reservations were created to provide them with accommodation, mainly in tents. These reservations came under the jurisdiction of the Aborigines' Protection Act, 1909 at such places as Pooncarie (near Menindee), Milparinka, Tibooburra and White Cliffs. The influenza epidemic in 1919 all but destroyed the remainder of the Aboriginal population of the west and those who survived were placed on a new reserve near Menindee in the 1930s. The remaining community of 70 Maliangapa people still living in their traditional corner country in 1936 was trucked east to Brewarrina against its will.

6.2 European occupation

European land settlement commenced in NSW in 1788 when Governor Phillip claimed possession of the land for a penal colony on behalf of the British Government. The historic accounts of the bioregional areas are diverse and detailed in the chapters on each bioregion. Further information on the European occupation of the Western Division bioregions is provided below.

(This section is largely based on HO and DUAP 1996: Chapter 16 of *Regional Histories of New South Wales*.)

Charles Sturt approached western NSW from South Australia in 1829, returning in the 1840s, while Thomas Mitchell approached from the north-east in 1835 (HO and DUAP 1996). The intensification of the squatting era in the 1840s occurred after squatters followed in the path of the explorers of the previous decade. Squatting continued until nearly 1900 (Denny 1994). The route often taken by overlanders, from the Namoi south to the Murray via the Barwon and Darling, required regular supplies and this prompted the birth of several small towns along the way (HO and DUAP 1996). By the mid-1840s, river frontages on the western section of the Murray and the lower Darling supported several pastoral stations. Aiding the development of these towns, the Commissioner of Crown Lands held offices first at Balranald in the late 1840s and later at Euston after 1853 (HO and DUAP 1996).

East of Bourke along the Upper Darling, settlement spread in the 1840s from the pastoral regions already established in the east, towards the west and north-west along the Bogan, Castlereagh, Namoi and Gwydir Rivers of the Darling Riverine Plains Bioregion (HO and DUAP 1996). The best grazing land was occupied along the Barwon and Mooni Rivers by 1850 and by 1859 on the east bank of the Warrego River and along the rivers up to and beyond the Queensland border. The arid area between the Culgoa and Warrego Rivers became occupied during the "land boom" of the early 1860s (HO and DUAP 1996).

Cattle remained the most significant element of the pastoral industry up to 1860. Sheep were present but were consistently outnumbered by cattle and since it appeared they could subsist on smaller land areas per head, were allocated much less land than cattle. While cattle comprised the dominant industry of the time, wool production was of significance in the 1850s, with local Aborigines an important part of this industry, using canoes to ferry wool across the Murray.

Steamboats began operating on the Murray in 1853 and their range was extended to the Darling in 1859. Although the Darling had been relatively ephemeral in the past, it was unusually full from this time and allowed riverboats to travel as far upstream as Brewarrina and beyond. Riverboats were known even to reach Queensland from the Darling via the Paroo River during times of flood. Wool was transported to the Victorian town of Echuca, where the riverboat route linked with the Victorian railway, and also by riverboat to Goolwa in South Australia. When the railway from Sydney reached the upper Darling in 1885, riverboats turned instead to Bourke and thus this town became an important destination for trade, continuing as the destination for wool trade until 1931 (HO and DUAP 1996).

The riverboat trade – and the movement of cattle overland before this – led to the development of several towns along the major rivers of the Western Division during the 1850s and 1860s. The Murrumbidgee saw the settlement of Balranald (gazetted in 1851), Hay (1859) and Maude (1861) in the Riverina Bioregion; Wentworth (1859) in the Riverina Bioregion and Menindee (1863) sprang up on the lower Darling in the Darling Riverine Plains Bioregion along with Wilcannia (1866) on the central Darling. The settlement of the towns of Walgett, Bourke, Brewarrina and Collarenebri occurred on the upper Darling and Barwon in the Darling Riverine Plains Bioregion from the late 1850s to mid 1860s. All of these towns remained fairly small even with the booming riverboat trade.

Like Aboriginal people before them, the new settlers were reluctant to inhabit vast areas of the Western Division away from the major rivers, due to unreliable access to water. Dams were attempted but were not often an option as the western plains lacked the rock formations offered by the land to farmers in the east (HO and DUAP 1996). In the north of the Darling Riverine Plains Bioregion, attempts were made around 1873 to dam the Narran River, but the river rebelled, refused orders to desist and within a few years had found an alternative route, defiantly bypassing the dammed section.

Other elements of the landscape were not so assertive, or had no escape from the control imposed by the settlers. For example, the red soils characteristic of the west quickly succumbed to trampling and compaction by grazing animals (HO and DUAP 1996). Graziers in the Bokhara River channel country near the Queensland border saw this change to the land favourably as it meant rainfall runoff reached the channels more readily. However, the improved flow in the channels wasted a lot of water and, ironically, compaction inhibited the growth of feed for the very stock that had trampled it in the first place.

Groundwater was available to some stations such as Kinchega station around Menindee Lakes in the lower Darling, which had access to the overflow lakes and flood channels near the Darling. The availability of water allowed the station to support around 143,000 sheep on 400,000 ha in the 1880s and the station employed many of the Barkindji people as shepherds (HO and DUAP 1996). Control of the water resources of the area allowed transportation of wool bales by water to the Darling.

The late nineteenth century brought innovations which helped to solve the water problem of the west. Wells were sunk in the 1860s along the stock route between the Darling and the Lachlan by the Public Works Department, which also made gradual improvements to water facilities in the far west. Graziers also sunk wells but salinity always caused problems: five out of six wells sunk on the western plains in the 1880s reached salt water at less than a depth of 30 metres (HO and DUAP 1996). The discovery of an extensive underground catchment – the Great

Artesian Basin – near Bourke around 1878, led to changes in the access to and use of water. From then on this vast water resource deep underground could be used for watering stock and, along the Lachlan and Murrumbidgee where the water was less saline, for irrigation (HO and DUAP 1996).

The artesian bores were particularly important resources from the 1880s to the graziers and overlanders in the west. The government sank bores from Bourke west through the Mulga Lands Bioregion to Wanaaring on the Paroo (HO and DUAP 1996). Across the west graziers sank private bores throughout the 1880s although, as happened with ordinary wells, these did not always yield bore-water. By 1895, this widespread bore sinking led the *Pastoral Review* to publish a regular column titled "Boring Notes".

This reliable and seemingly unlimited water source changed the settlement of the west, giving landholders and industry the confidence to expand. In fact, this access to water in the far west enabled the significant mineral discoveries of the corner country at Tibooburra, Milparinka and of course, Broken Hill (HO and DUAP 1996).

By 1910 there were 364 artesian bores in NSW, which every day harnessed about 500 million litres of water from the Basin. Since then, the number of bores has increased although the total amount of water flowing has progressively decreased, falling by 35% between 1915 and 1958 (HO and DUAP 1996). In the north, where the water is least saline, the Basin still provides the water supplies for the towns of Walgett and Lightning Ridge.

The discovery and exploitation of the Great Artesian Basin, although an immense advantage for the graziers of the west, spelt trouble for the landscape. Access to so much water encouraged overstocking, and just prior to the devastating drought of the 1890s, the western plains supported about 15 million sheep. Sandstorms intensified by erosion due to overstocking caused silt to block tanks and channels. This increased the expenses of installation and maintenance of the bores and drained the economic resources of local graziers (HO and DUAP 1996). Rabbits, encouraged by the plentiful water supply, ran rampant in the west, competing with the stock for food. By 1902 sheep numbers on the western plains had dropped to five million, one-third of their former magnitude.

The Western Division, as well as its Central and Eastern counterparts, was a creation of the Crown Lands Act, 1884. Economic and social collapse during the drought and recession of the 1890s (Cambell 1994) prompted a Royal Commission into the Western Division which repealed the *Crown Lands Act* and conceived the *Western Lands Act*, 1901.

The aim of the Western Lands Act was to manage and control the western land resource, and included the creation of a lease system to enable rural and urban development in the Western Division of NSW. This established a system of leasing and administering land that was more relevant to the western landscape than land management undertaken previously in the Western Division. Most of the land in the Division is held under perpetual leasehold as Western Lands Leases from the Crown for the purpose of grazing, with some small areas held under Special Leases for agriculture, freehold or in reserves (Cambell 1994, Hyder Consulting 1999). The Act does not apply to freehold land in the Western Division. Since its inception, the Act has undergone several reviews designed to re-evaluate its direction and implement improvements to its functionality, the most recent being in 1999 (Hyder Consulting 1999).

The Western Division of NSW covers around 32,500,000 hectares or 42 per cent of the State (Hyder Consulting 1999). The boundary of the Division traverses the Darling Riverine Plains, Cobar Peneplain, Riverina and Murray Darling Depression Bioregions. The Western Division boundary has mainly leasehold lands to the west and freehold lands to the east and this results in fairly significant differences in the management and subsequent condition of land on either side of the boundary. The Central Division lands to the east have been extensively cleared and intensely cultivated compared to the Western Division lands (Masters and Foster 2000). Dryland and irrigated agriculture has become more common in recent years, particularly along the rivers of the Western Division (Hyder Consulting 1999).

The landscapes of the Western Division are diverse, having adapted to the semi-arid climate of high summer temperatures coupled with low and irregular rainfall. Inappropriate land management of the Western Division in the past has led to degraded habitats and loss of species (Hyder Consulting 1999). In 1996 the population of the Western Division was 52,830, a figure which had declined by more that 5,000 in the preceding 15 years, a loss attributed mainly to the decline of mining in the Broken Hill area. However during this time, the Aboriginal population had increased by about 65 per cent to around 5,000 (Hyder Consulting 1999).

The most recent Western Lands Review was established to "identify issues impacting on long term sustainable management and recommend actions to enhance such management" as well as to "resolve land administration problems and to develop greater flexibility in rural land use" in the Western Division (Hyder Consulting 1999).

7. Subregions

A description of the subregions of each bioregion is presented in a table in each chapter. These descriptions are based on the work of Morgan and Terrey (1992) and Morgan (2001). The subregions are a major natural land-use planning unit that can assist in conservation planning at a regional scale.

8. Conservation status

There is such a wide variety of conservation mechanisms and programs available, that when comparing their effectiveness in conserving the range of landscapes across the State, we need to consider the following:

- the date that the mechanism/program commenced; for example, the Wildlife Refuge program in NSW has been in existence for a much longer period of time than the Voluntary Conservation Agreement program or the Property Agreement program;
- accompanying incentives for private land programs; for example, the Voluntary Conservation Agreement program has generally not been accompanied by the financial and other incentives that accompany the Property Agreement program but is important for conserving cultural heritage as well as biodiversity which the Property Agreement program is not;
- the scope of the program; for example, National Parks protect a broad range of natural features but mechanisms such as Karst Conservation Reserves, Aboriginal Areas and Historic Sites have a more specific focus.

For these reasons we have described what is achieved in terms of the representation of landscapes in these mechanisms but have not necessarily found it useful to use this information alone to compare the effectiveness of different programs.

8.1 The role of National Parks and Nature Reserves

National Parks and Nature Reserves have the highest security (are permanently reserved) and are managed primarily for conservation. (Flora Reserves are also important in this regard although some Flora Reserves may permit mining.)

National Parks and Nature Reserves occur in all of the NSW bioregions. National Parks and Nature Reserves generally protect the largest area of land and the largest range of landscapes in each bioregion. The exceptions are the Darling Riverine Plains and Riverina bioregions, where Wildlife Refuges contain more land and a greater range of landscapes than in the National Park and Nature Reserve system. In the Channel Country and Mulga Lands bioregions, National Parks and Nature Reserves make a greater contribution in terms of area, while the Wildlife Refuge program contributes to the management of a greater variety of landscapes.

In the NSW Australian Alps, National Parks and Nature Reserves are the major component of the bioregional landscape (90.38%) and are also a large component of the bioregional landscape of the Sydney Basin (35.35%) and the NSW portion of the South East Corner (42.29%). The largest area, approximately 991,386 ha, falls in the NSW North Coast Bioregion. The remaining bioregions have less than 30% of their NSW area in National Parks and Nature Reserves, with the majority having less than 5% of their area within this system. The least reserved bioregions are the Riverina (0.32%) and Darling Riverine Plains (0.93%).

Currently the goals for National Parks and Nature Reserves in NSW are to incorporate the full range of landscapes within the bioregions and to ensure as much as possible that sufficient areas of these landscapes are conserved to allow them to function and persist for hundreds of years.

Photo: A. Brown

Even in the Australian Alps Bioregion, where the level of reservation is highest, the full range of landscapes is still not included in the conservation mechanisms surveyed.

8.2 The role of Wilderness Areas

Wilderness Areas are managed for the protection of an area's "wilderness" qualities. Declared Wilderness Areas provide a high level of protection for landscapes contained by them, but do not increase the total area of landscapes protected by conservation mechanisms. This is because wilderness, in all but one instance, has been declared over existing National Parks (the exception being a Wilderness Protection Agreement/Voluntary Conservation Agreement in the South Eastern Highlands Bioregion).

8.3 The role of Flora Reserves

Flora Reserves are managed primarily for flora conservation. In many cases these offer a similar level of security and protection to biodiversity as National Parks and Nature Reserves, although in some cases mining may be permitted

in them. Flora Reserves are present in 12 of the 17 NSW bioregions. The largest area of any of the bioregions occupied by Flora Reserves is in the NSW North Coast where 7,510 ha or 0.13% of the bioregion is contained by Flora Reserves.

8.4 The role of Voluntary Conservation Agreements

Voluntary Conservation Agreements are represented in 10 of the 17 NSW bioregions. These are on private land, are voluntary, and are permanently on the title of the land, and despite their relatively small size (on a bioregional scale) in some bioregions, they contribute to protection of landscapes which are otherwise not included in conservation mechanisms. The largest area of any of the bioregions occupied by Voluntary Conservation Agreements, by area and by percentage of bioregion, is in the South East Highlands Bioregion, where 2,889 ha or 0.06% of the bioregion has been protected by landholders.

8.5 The role of Property Agreements

Property Agreements occur in 12 of the NSW 17 bioregions. The largest area of any of the bioregions occupied by the conservation zone of Property Agreements is in the South Eastern Highlands Bioregion, where 6,354.29 ha or 0.13% of the bioregion has been contained by these agreements.

8.6 The role of Wildlife Refuges

Apart from National Parks and Nature Reserves, Wildlife Refuges are the only conservation mechanisms to operate across all NSW bioregions. Wildlife Refuges occupy a larger proportion of the South Eastern Highlands Bioregion than either Voluntary Conservation Agreement or Property Agreement programs. A total of 68,776.84 ha or 1.41% of the South Eastern Highlands Bioregion is contained by Wildlife Refuges. The Wildlife Refuge program achieves the greatest proportion of bioregional conservation in the Simpson Strzelecki Bioregion, with 128,778.63 ha or 6.08% of its area, and the Channel Country Bioregion, with 74,518.13 ha or 5.21% of its area.

8.7 The role of Regional Parks

The only bioregion containing Regional Parks is the Sydney Basin Bioregion where they occupy 4,675 ha or 0.13% of the bioregion. In this bioregion, Regional Parks expand on the conservation of landscapes that are also included in the system of National Parks and Nature Reserves, and contribute as much area as these to the protection of some landscapes that are under-represented in the bioregion.

8.8 The role of Crown Reserves

Crown Reserves operate across 6 of the bioregions, all in the east of the State. In all cases, Crown Reserves expand the area of landscapes that are also included in the system of National Parks and Nature Reserves. Crown Reserves achieve the greatest proportion of bioregion conservation in the NSW North Coast Bioregion, where they occupy 21,862 ha or 0.38% of the bioregion.

8.9 The role of Historic Sites

Historic Sites are present in almost half of the NSW bioregions. They are generally small areas set aside to conserve historic heritage. They generally contribute to the conservation of landscapes also represented in the system of National Parks and Nature Reserves.

8.10 The role of Karst Conservation Reserves

Karst Conservation Reserves are found only in the NSW South Western Slopes and South Eastern Highlands Bioregions. They target very specific landscape features and are small areas which slightly expand the areas of landscapes also conserved in the system of National Parks and Nature Reserves.

8.11 The role of Aboriginal Areas

Aboriginal Areas occur in only 4 of the bioregions: Channel County, North Coast, Simpson-Strzelecki Dunefields and Sydney Basin. The largest area protected by this mechanism is in the Channel Country, with 9,387.15 ha or 0.66% of the bioregional area included.

9. Representativeness of conservation mechanisms

In general, conservation mechanisms tend to focus on the same landscapes. The additions to the range of landscapes represented in National Parks and Nature Reserves, in decreasing order, are as follows:

- in 15 of the bioregions, the Wildlife Refuge Program has increased the range of landscapes represented (while also overlapping with National Parks and Nature Reserves in other bioregions);
- in 10 of the bioregions, Property Agreements have increased the range of landscapes represented in National Parks and Nature Reserves;
- in 6 of the bioregions, Flora Reserves have increased the range of landscapes conserved;
- in 4 of the bioregions, Voluntary Conservation Agreements have increased the range of landscapes conserved.

There has always been overlap between the types of landscapes conserved by Crown Reserves, National Parks and Nature Reserves in each bioregion. Property Agreements and Wildlife Refuges also conserve similar landscapes in each bioregion.

10. Effectiveness of conservation mechanisms

In most cases, the landscapes have not reached even a conservative level (20% of their bioregional area) of representation in any of the conservation mechanisms let alone within the system of National Parks and Nature Reserves. To this extent, the overlaps in types of landscapes protected outside of the reserve system are potentially important complementary contributions to achieving long-term conservation of landscapes. Nevertheless, there is still considerable scope for further representation of landscapes already included in the conservation mechanisms surveyed. Wider targeting not only of the National Parks and Nature Reserves but other off-park conservation programs will help to achieve this.

There are still many landscapes in NSW that are not protected by any of the available conservation mechanisms. All bioregions contain some landscapes that are not protected. Only in the Australian Alps Bioregion is the full range of landscapes almost achieving some representation, but even in this bioregion, where a large percentage of its area is reserved, there are still some landscapes that are not protected.

State forests are described in the bioregional summaries of conservation status (Section 9 of each chapter) to provide a comparative picture of land management (Ecologically Sustainable Forest Management or ESFM). In addition, Flora Reserves are identified as the formal reserve component of the estate. Other conservation mechanisms that occur on the SFNSW estate (including informal reserves and protection by prescription) have not been individually identified at the landscape scale because of the complex interplay of conservation mechanisms and resource management.

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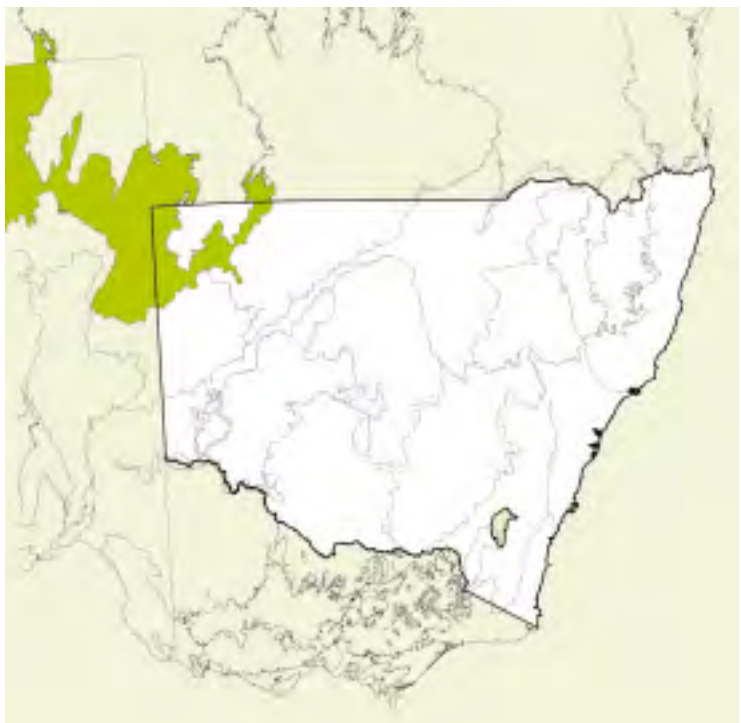

CHAPTER 2

The Simpson-Strzelecki Dunefields Bioregion

1. Location

At a total area of 29,722,724 ha, the Simpson-Strzelecki Dunefields Bioregion extends from the southeast of the Northern Territory, through the northeast of SA, with small areas in both Qld and NSW. The far northeast corner of NSW is occupied by the bioregion with an area of 2,116,980 ha, which constitutes 7.12% of the entire bioregion and covers 2.65% of the state.

In NSW the bioregion is bordered by the Channel Country Bioregion in the north and by the Broken Hill Complex and Mulga Lands bioregions in the east and south.

There are no townships in the bioregion, although popular tourist spots include Camerons Corner at the junction between SA, Qld and NSW, as well as the nearby Fort Grey (at Lake Pinaroo), where Charles Sturt is reported to have built a defence against local Aborigines (NSW NPWS 1991). Both of these sites fall in Sturt National Park.

The bioregion includes parts of the Lake Frome and Bulloo catchments (Morgan and Terrey 1992).

2. Climate

The Simpson-Strzelecki Dunefields Bioregion is very arid and has unpredictable rainfall, which generally averages from 150-200 mm per year (Morgan and Terrey 1992). It is one of four bioregions, all in the far northwest of the state, that are dominated by a hot, persistently dry desert climate (Stern *et al.* 2000).

3. Topography

The Simpson-Strzelecki Dunefields are part of the Australian continental dunefields, which consist of a huge anti-clockwise whorl of linear dunes in central Australia. Most of the dunefield lies in the Lake Eyre Basin and the edge of the region extends into the NSW corner country. The region is dominated by high linear dunes of red sand.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
19 – 21°C	4.6 – 5.5°C	34.9 – 37.7°C	130 – 249mm	5 – 13mm	19 – 45mm

4. Geology and geomorphology

The dunes and sandplains of this bioregion developed on Tertiary and Quaternary alluvial sediments. Thinner sheets of wind-blown sand that blanket the landscape as sandplains do not have a marked dune structure. In NSW, the dunes are formed by a westerly wind that moves sand from distant lake shores and reworks sand from the alluvial systems. Most dunes are stable, but higher dunes, and those subject to land degradation by grazing, have active crests. Dune spacing varies from 50 to 500m and the intervening swales may expose underlying stony plain, deep alluvial sands and clays, or calcareous sandy soils. The original source of the dune sands is generally considered to be the Great Dividing Range, with the sand being delivered by rivers through the Cooper Creek and Bulloo systems. There are few rock outcrops in the sand dune country other than small flat-topped hills of Cretaceous or Tertiary sediments.

Both the dunefields and the sandplains contain clay pans and ephemeral lake beds. Stream channels from the Tibooburra and Barrier Ranges flow toward Lake Callabonna and Lake Frome in northeastern SA and flood local claypans, but runoff is now insufficient to reach the distant lakes. Sands in the eastern part of the region are derived from the Bulloo overflow where they are associated with larger lake basins that contain well-developed beaches and lunettes. Over the past 30,000 years variable climates have allowed greater dune mobility, more active streams and periods with full lakes. Details of this chronology are not well known for this area.

5. Geodiversity

Arguably, the Simpson-Strzelecki Dunefields Bioregion is the largest example of a linear sand dune environment in the world.

Important features of this bioregion include the following:

- Tertiary vertebrate fossils in river and lake sediments such as the well-known Diprotodon sites at Lake Callabonna (SA), and well-preserved flora in silcretes such as the Miocene eucalypts from Sturt Creek, south of Lake Eyre; no comparable sites have been documented in NSW, although silcretes in the corner country are known to contain Tertiary plant fossils;
- the dune country of Sturt National Park contains stone quarry sites on patches of gibber as well as numerous open campsites in the dunefields and on ephemeral lakes, swamps and streams; even the most extreme climatic zones have been occupied by Aboriginal people who used shallow seepage wells in inter-dune corridors; archaeological dates can place some constraints on ages of dune activity, but few have been obtained from this environment in NSW; and
- the mound springs that occur on the margins of the dunefields in other states and many of the salt lake basins are groundwater windows; little is known of groundwater systems in this part of NSW.

6. Soils

The dunes have only minimal soil profile development as red siliceous sands, although the dune cores contain more clay and soil carbonate. Soils are better developed in the swales, along the creek lines and in the lake beds where fine alluvial sediments accumulate to form cracking brown or grey clays, harsh texture contrast profiles, and sandy red earths.

None of the soils contains high quantities of plant nutrient although the clays are better than the sands. Soil moisture retention is also better in the clays, but some clays contain high levels of soluble minerals such as gypsum and common salt that limit plant growth.

7. Biodiversity

7.1 Plant communities

The sand dunes of the western half of Sturt National Park in the bioregion support a perennial woodland community dominated by *Acacia ligulata*, mulga, needlewood (*Hakea leucoptera*), whitewood (*Atalaya hemiglauca*) and beefwood (*Grevillea striata*). The woodland understorey is a shrubland consisting of species of *Cassia*, *Eremophila* and *Dodonaea*. Mitchell Grass also occurs on the dunes while temporary canegrass (*Glyceria ramigera*) – lignum (*Muehlenbeckia cunninghamia*) swamp communities occur between them.

Photo: G. Robertson

The sand dunes and sandplains support sandhill wattle (*Acacia ligulata*), turpentine (*Eremophila sturtii*), scattered mulga (*Acacia anuera*), rosewood (*Heterodendrum oleifolium*), whitewood (*Atalaya hemiglauca*), canegrass (*Eragrostis australasica*), the occasional white pine (*Callitris glaucophylla*) and various cassia and eremophila species.

Lignum (*Muehlenbeckia cunninghamia*), black box (*Eucalyptus largiflorens*) and river red gum (*Eucalyptus camaldulensis*) grow along the creeks and on the margins of freshwater claypans. Many of the same species are found in the more saline clays of the Cobham land system along with prickly wattle (*Acacia victoriae*) and chenopods. Bladder saltbush (*Atriplex vesicaria*), black bluebush (*Maireana pyramidata*), Mitchell grass (*Astrebla* sp.) and scattered mulga (*Acacia anuera*) are found on the tablelands and stony downs. Bimble box (*Eucalyptus populnea*), western bloodwood (*Eucalyptus terminalis*) and ironwood (*Acacia excelsa*) are present with denser mulga on the sands of the Bulloo Dunefield.

7.2 Significant flora

Seven species found in the bioregion are listed in the TSC Act 1995. Of these, five are listed as endangered and two are listed as vulnerable. A further three species, *Glinus orygioides, Osteocarpum pentapterum* and *Senecio georgianus,* which previously occurred in Sturt National Park, are now considered extinct in NSW (NSW NPWS 2001).

7.3 Significant fauna

Forty-one fauna species found in the bioregion are listed in the schedules of the TSC Act. Of these, 12 are listed as endangered and 27 are listed as vulnerable. Two species, the pig-footed bandicoot (*Chaeropus ecaudatus*) and the burrowing bettong (*Bettongia lesueur*), are presumed extinct in the bioregion.

Although sand dunes are not generally home to a high diversity or number of birds, the bioregion supports a few distinct species. These include Eyrean grasswrens (*Amytornis goyderi*) which occur in cane grass on dunes (Australian Terrestrial Biodiversity Assessment 2002), as well as species characteristic of chenopod shrublands, many of which are threatened in other bioregions (Morton *et al.* 1995). In contrast to others, this bioregion shows little evidence of environmental change and supports few exotic bird species (Australian Terrestrial Biodiversity Assessment 2002).

Some waterbirds, such as the vulnerable painted snipe (*Rostratula benghalensis*), have been recorded here (Australian Terrestrial Biodiversity Assessment 2002), indicating a higher than average rainfall in this arid bioregion. During wet periods, many itinerant waterbirds breed on the ephemeral inter-dune swamps, although declines have been recorded in numbers of freshwater species and migratory waders (Australian Terrestrial Biodiversity Assessment 2002).

Feral animals threaten the biodiversity of the bioregion, with rabbits being particularly problematic.

7.4 Significant wetlands

Sturt National Park wetlands are a good example of canegrass claypans in dunefields and occur at the western end of Sturt National Park with mainly sparse vegetation dominated by canegrass (*Eragrostis australasica*), lignum (*Muehlenbeckia spp.*) and chenopods (*Chenopodium spp.*). Fort Grey basin and overflow swamps occur in this area and support large numbers of waterbirds (ANCA 1996). The wetlands are considered to be in good condition and are improving despite the presence of feral animals and weeds (Australian Terrestrial Biodiversity Assessment 2002).

The Salt Lake is a terminal salina, which is occasionally inundated for long periods. The water is saline, becoming more concentrated as evaporation occurs, and provides a representative example of a hypersaline lake. When full, more than 70,000 waterbirds have been recorded on the lake (Kingsford *et al.* 1994; cited in ANCA 1996) although the lake is usually dry and supports little vegetation. Submerged algae and sea tassel (*Ruppia* sp.) can be found when it is flooded (ANCA 1996).

Paldramata Lake is another significant wetland in the bioregion. In December 1989, the lake supported 4,200 waterbirds and in March 1993 over 2,000 waterbirds were recorded (Australian Terrestrial Biodiversity Assessment 2002). The most abundant species included Eurasian coot (*Fulica atra*), pink-eared duck (*Malacorhynchus membranaceus*) and hardhead (*Aythya australis*). Waterbirds recorded at the lake include the vulnerable freckled duck (*Stictonetta naevosa*) (Kingsford *et al.* 1994).

The lakes in the bioregion are considered to be in good condition (Australian Terrestrial Biodiversity Assessment 2002). Threats are present, however, and include impacts from grazing pressure, feral animals and exotic weeds.

8. Regional history

For information on the regional history of the Simpson-Strzelecki Dunefields Bioregion refer to Chapter 1 under the heading “Regional history”.

9. Bioregional-scale conservation

Only a few of the possible conservation tenures are deployed in this bioregion. Those that are occupy 253,211 ha or 11.96% of the bioregion. The parts of Sturt National Park and Pindera Downs Aboriginal Area that are located within the Simpson-Strzelecki Dunefields are the only reserves managed under the NPW Act 1974 in the bioregion. They occupy 122,030 ha or 5.76% and 2,403 ha or 0.11% of the bioregion respectively. These are not managed additionally for wilderness values, as there are no declared wilderness areas in the bioregion.

Some landholders in the bioregion have entered into private land conservation under the provisions of the NPW Act 1974. There are four wildlife refuges on properties occupying about 128,779 ha or 6.08% of the bioregion but there are no voluntary conservation agreements. Nor are there any property agreements under the NVC Act 1997 in the bioregion.

No land, in the form of either State forest or flora reserve, is managed for conservation or for forestry under the Forestry Act 1916.

10. Subregions of the Simpson-Strzelecki Dunefields Bioregion

(Morgan and Terrey 1992)

Subregion -	Geology	Characteristic landforms	Typical soils	Vegetation
Western Dunefields Parts of 9 land systems.	Quaternary aeolian sand, minor alluvial sediments, and small areas of Cretaceous or Tertiary bedrock.	High parallel, linear dunes with streams and lakes extending from the ranges through the inter-dune depressions. Most lakes are freshwater. Small areas of stony plain.	Deep red quartz sands on dunes, heavy clays along stream lines.	Sandhill wattle, mulga, turpentine, hopbush, rosewood, and canegrass occur on dunes and swales. Prickly wattle, canegrass, black box, and river red gum on creeks and lakes. Bladder saltbush, black bluebush, Mitchell grass, mulga, whitewood, turpentine and hopbush are present on stony plains.
Central Depression Parts of 12 land systems.	Complex of Quaternary aeolian sands, alluvial and lake beds with well-developed beaches and lunettes.	Low sand dunes of variable orientation and shape, extensive sandplains. Large lake basins with fringing lunettes, some saline lakes possibly linked to groundwater.	Deep quartz sands on dunes, sand and clay lunettes, heavy clays along stream lines.	Mulga, whitewood with canegrass on dunes and black bluebush in swales. Mulga, whitewood, prickly wattle, black box, canegrass and river red gum along creeks. Canegrass, lignum, prickly wattle, black box, old man saltbush and thorny saltbush occur on lakes. Lunettes support open mulga, turpentine and pearl bluebush.
Bulloo Dunefields Parts of 11 land systems.	Quaternary aeolian sands from local sources, alluvial and lake sediments, with outcrops of Cretaceous or Tertiary bedrock.	Sandplains and low dunes, marginal to extensive areas of floodout country. Tablelands and stony downs on bedrock.	Deep red to yellow quartz sand, heavy clays in alluvial areas. Stony loams on downs.	Mulga, whitewood, ironwood, bimble box, and canegrass are present on sandplains. Mulga, bimble box, grasses and forbs occur on floodouts. Mulga, dead finish, desert poplar, silver cassia, punty bush, turkey bush, bluebush and grasses occur on tablelands and downs.

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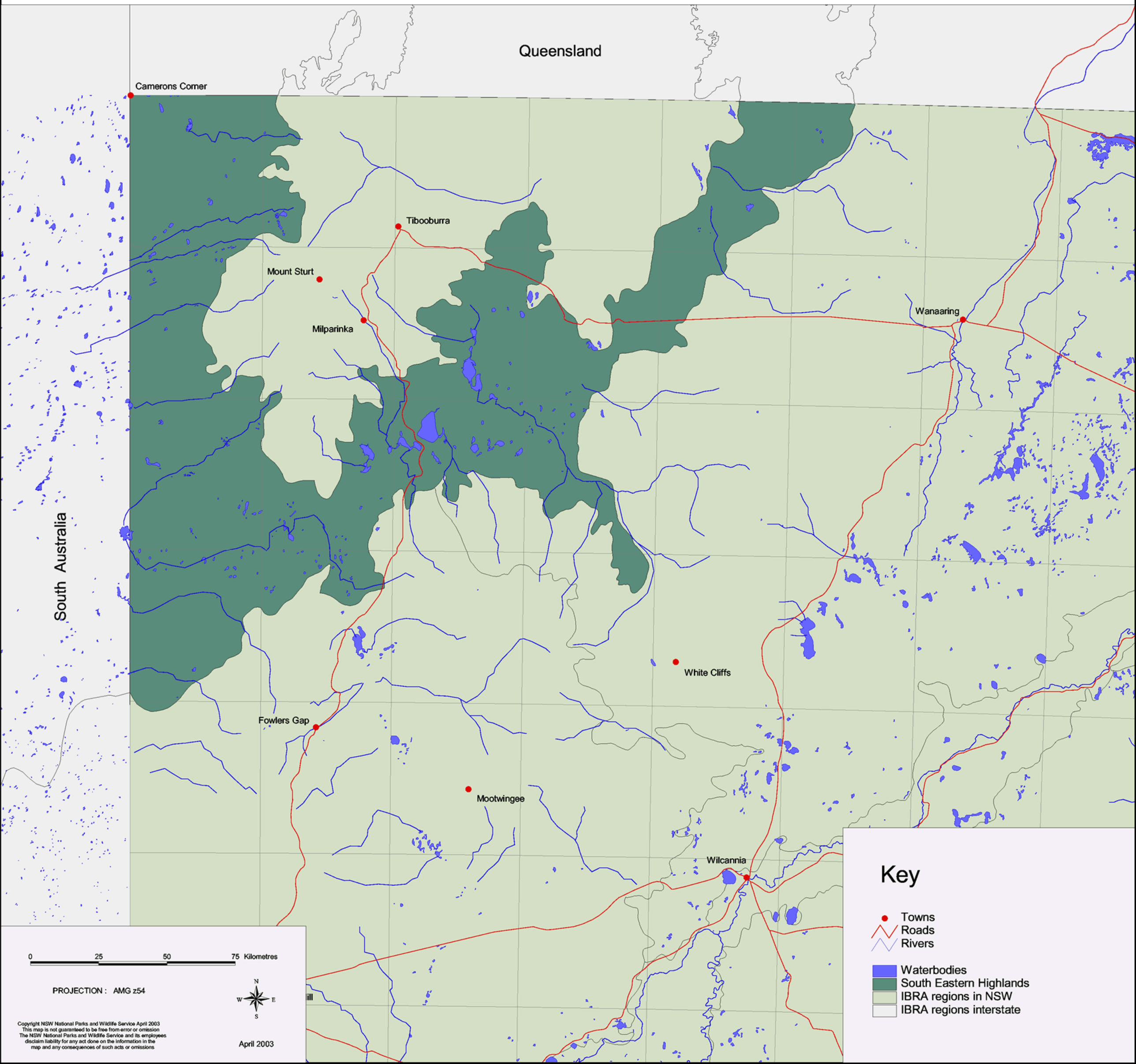
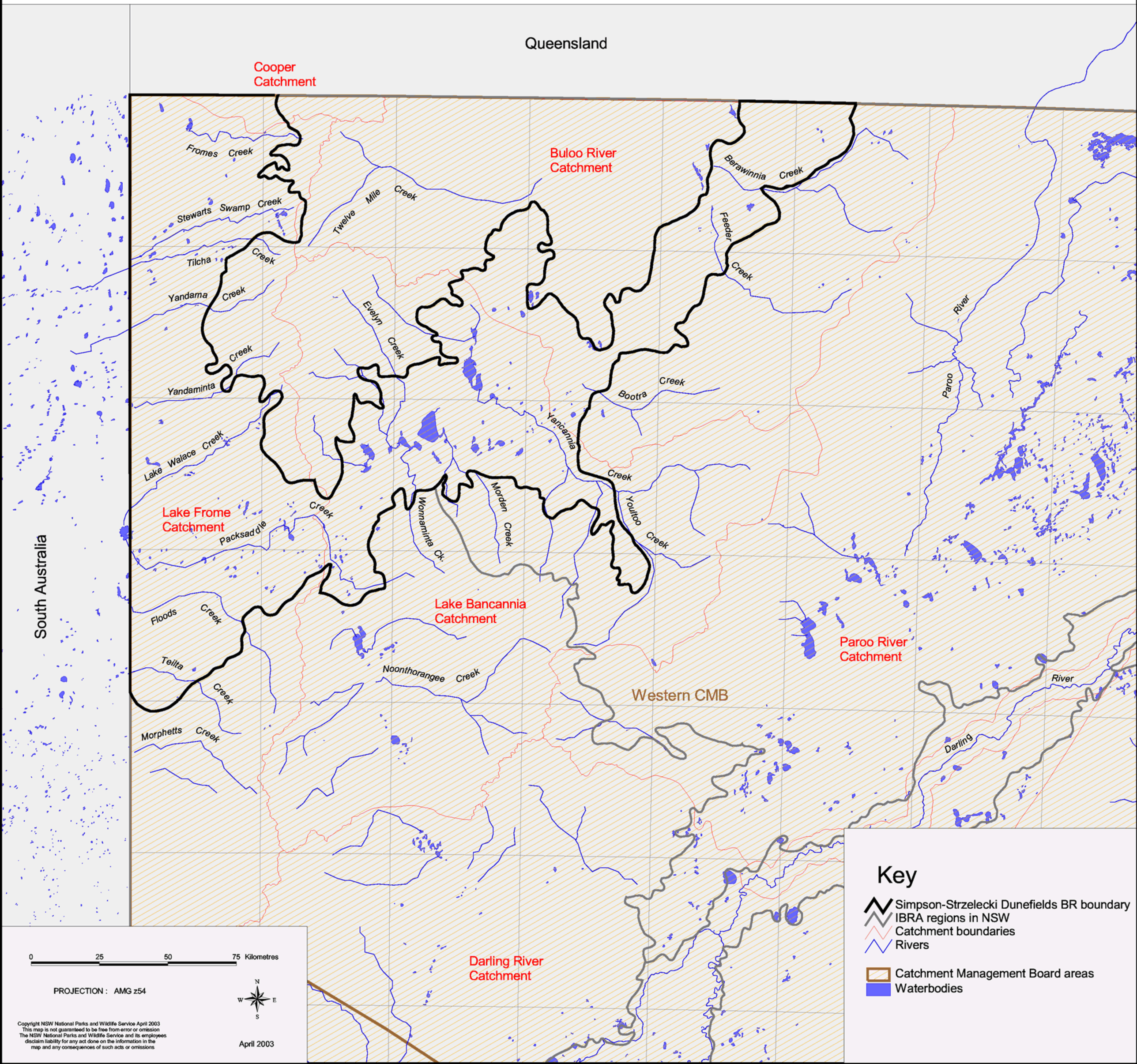
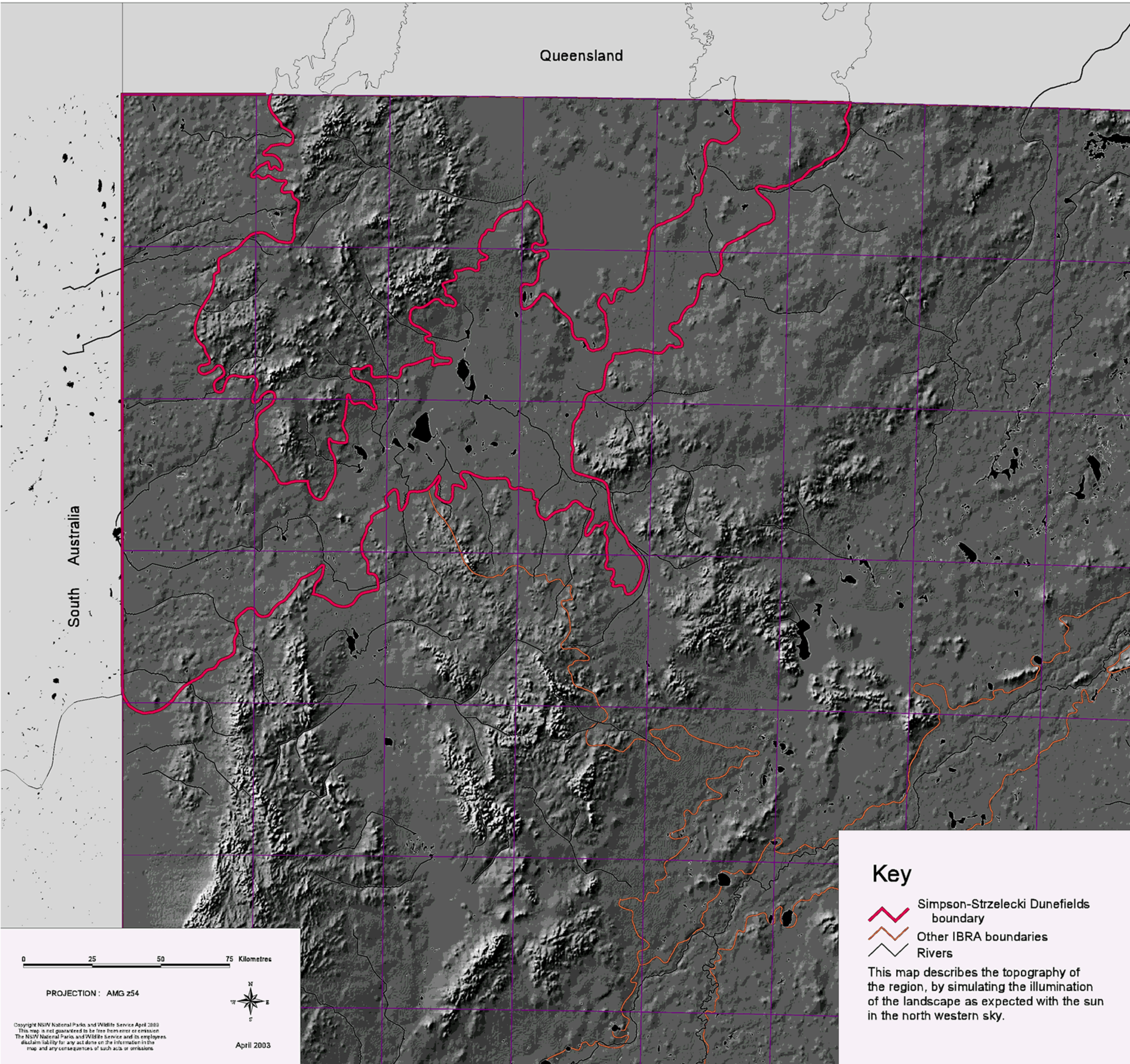
Simpson - Strzelecki Dunefields Biogeographic Region (IBRA) - Location



Simpson - Strzelecki Dunefields Biogeographic Region (IBRA) - Rivers



Simpson-Strzelecki Dunefields Biogeographic Region (IBRA) - Topography



0 25 50 75 Kilometres

PROJECTION : AMG z54

N
W E
S

April 2003

Key

Simpson-Strzelecki Dunefields boundary

Other IBRA boundaries

Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

Simpson - Strzelecki Dunefields Biogeographic Region (IBRA) - Vegetation

Queensland

South Australia

Cobar
(proposed)

Key

- Simpson - Strzelecki Dunefields BR boundary
- Roads
- Rivers
- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

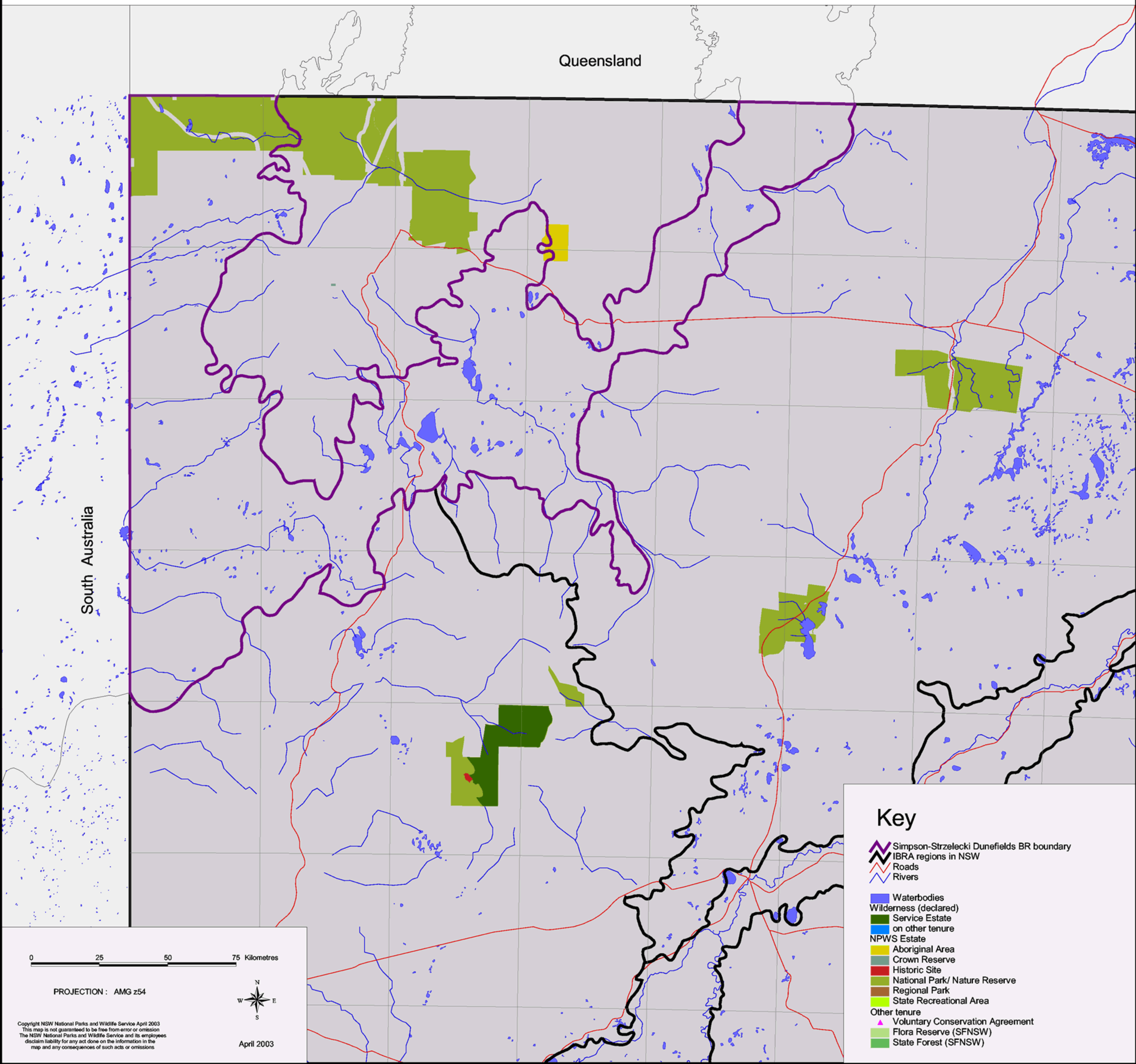
0 25 50 75 Kilometres

PROJECTION : AMG z54

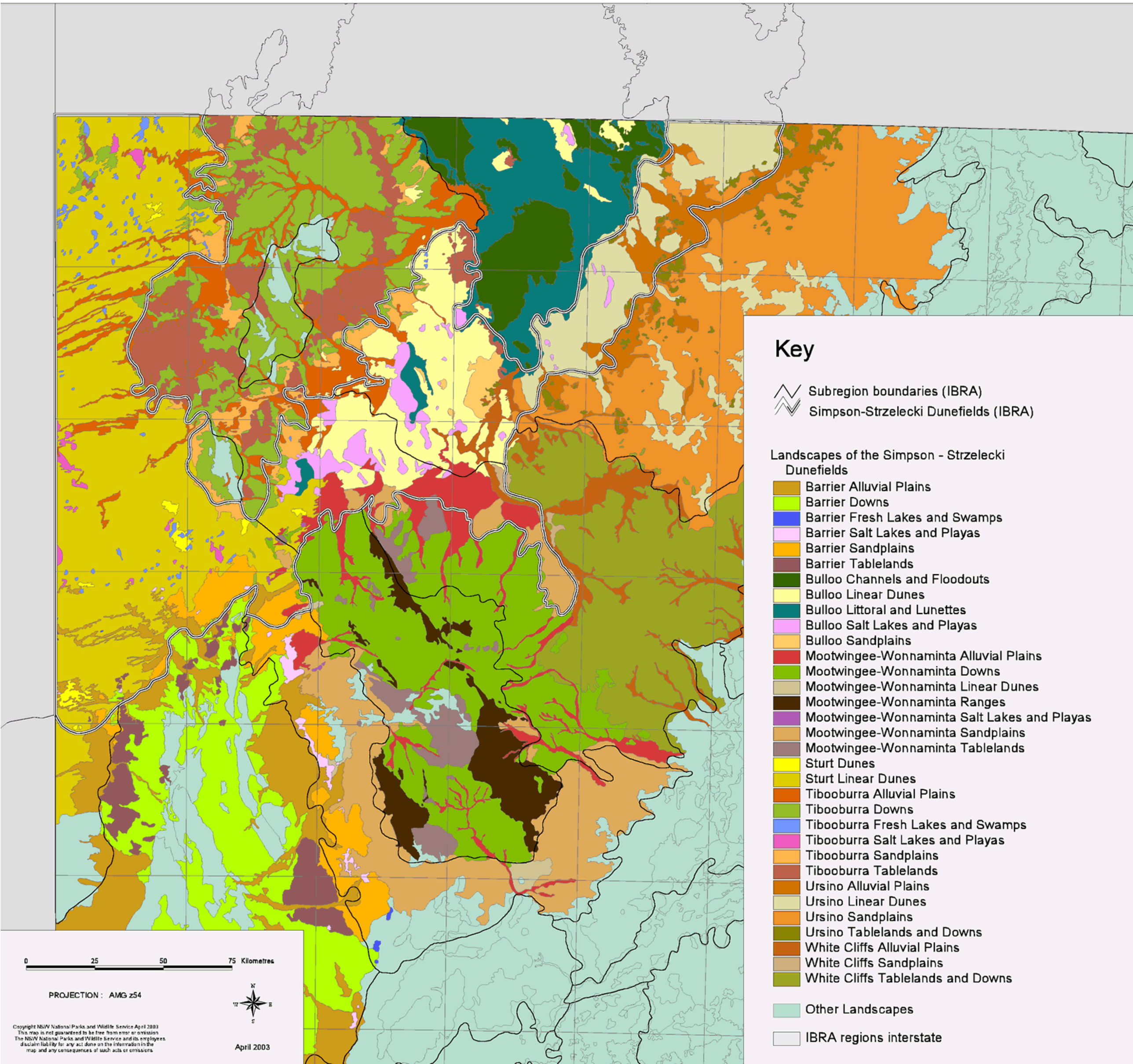
N W E S

April 2003

Simpson-Strzelecki Dunefields Biogeographic Region (IBRA) - Tenure/Reserves



Simpson-Srzelecki Dunefields Biogeographic Region (IBRA) - Subregions and Landscapes (Mitchell, in preparation)



CHAPTER 3

The Channel Country Bioregion

1. Location

The Channel Country Bioregion is one of few bioregions that span several Australian states. Its 28,885,384 ha incorporate an area in the NT, a large section of southwest Qld, the northwest corner of SA as well as a small section in the far northwest of NSW. The 1,429,584 ha area covered in NSW is minimal, constituting 4.95% of the entire bioregion and 1.78% of the state. In NSW the bioregion is entirely surrounded by the Simpson-Strzelecki Dunefields Bioregion.

The bioregion lies in the Western Division and is traversed by the Silver City Highway, which runs through Milparinka and Tibooburra and south to Broken Hill in the Broken Hill Complex Bioregion.

The bioregion straddles four catchments: Bulloo River, Cooper Creek, Lake Frome and Lake Bancannia but does not extend to the Murray-Darling Basin.

2. Climate

The Channel Country Bioregion is one of four NSW bioregions that fall in the arid zone. This climate is characterised by hot temperatures and a persistently low rainfall: the bioregion is known to receive erratic rainfall that usually averages little more than 200 mm per year (Morgan and Terrey 1992).

3. Topography

The Channel Country Bioregion is a region of extensive stream systems draining to Lake Eyre. Multiple river channels, very wide floodplains and large waterholes crisscross this subdued landscape of gibber plain, low stony rises and dunefields. Tertiary and Quaternary sediments form the extensive stony plains between low tablelands and mesas of Mesozoic sandstones. The climate is extremely arid and the vegetation sparse. Floods are infrequent but, when they occur, major events trigger huge breeding and growth responses in the biota.

4. Geology and geomorphology

The NSW part of the bioregion is atypical geologically in that it contains three small areas of older bedrock at the core of the Mt Arrowsmith – Tibooburra Ranges. These outcrops of late pre-Cambrian and Cambrian rocks reflect a ridge of high bedrock running from Mt Koonenberry to Tibooburra that separates two parts of the Great Australian Basin; the Lake Frome embayment in the east and the Bulloo embayment in the west. The Tibooburra granodiorite has weathered to low hills covered with rounded boulders or tors, with low ridges of resistant quartz veins.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
19 – 21°C	4.6 – 5.4°C	35 – 37.2°C	149 – 216mm	7 – 12mm	23 – 34mm

Marginal to the basement rocks, the Mesozoic and Tertiary sediments form a series of tablelands and mesas with shallow stony soils and prominent low cliff lines of silicified sandstones. Claystones underlie the lower slopes.

Drainage from the hills runs into the Simpson-Strzelecki Dunefields Bioregion on the west and into the Bulloo Overflow on the east. The Bulloo Overflow is a complex of terminal channels, floodplains and lake basins of the Bulloo River. It is dominated by Quaternary sediments of clays in the channels and lakes and sand reworked by wind into lunettes, sand sheets and some dunes. This area of deposition was the source for sand that is now in the Bulloo Dunefield subregion (Simpson-Strzelecki Dunefields Bioregion) and the Ursino Sandplains subregion (Mulga Lands Bioregion).

5. Geodiversity

Important features of this bioregion include the following:

- the rounded tors of granodiorite on the hills combined with the tableland scarps, extensive surface cover of rounded siliceous pebbles (gibber), and contour banding on the downs country, make these landscapes unusual in arid NSW;
- the Bulloo Overflow is an important ephemeral wetland in the extreme arid zone, and the lunettes on the lakes contain important evidence of climate change and human occupation; and
- several areas of basement rocks in the ranges have supported small goldfields in the late nineteenth century and retain heritage structures associated with mining.

6. Soils

Soil development is limited to shallow, stony, gritty loams on the bedrock hills. On the Cretaceous sediments, yellow-brown to brown loams with stony surfaces are common on the sandstones, and sticky grey-green clays with high carbonate and gypsum content, or shallow stony texture contrast soils are found on the claystones on the lower slopes. Most slopes are contour banded with areas of stony soil alternating with deeper stone-free brown loams.

In floodout areas from the ranges, brown loamy clays occur with thin patches of red sand and low dunes marginal to the creeks. In the Bulloo Overflow, grey cracking clays, often saline, are the norm for the fluvial areas, with pale red sands and earthy sands in the sandplains to the east. Soils and sediment on the lunettes are more complex and similar to those on lunettes in the Menindee Lakes.

7. Biodiversity

7.1 Plant communities

Vegetation growth in arid and semi-arid zones such as the Channel Country is limited by rainfall. The ranges support open bluebush (*Maireana* sp.) communities with sandalwood (*Santalum lanceolatum*), dead finish (*Acacia tetragonophylla*), western pittosporum (*Pittosporum phylliraeoides*), copperburr (*Bassia* sp.) and sparse mulga (*Acacia aneura*). The lower slopes, tablelands and downs carry open mulga and belah (*Casuarina cristata*) patches, bluebush and bladder saltbush (*Atriplex vesicaria*), with Mitchell grass (*Astrebla* sp.) and other annuals growing on the stone-free steps of the contour bands in good seasons.

Much of the downs country often appears bare. Streams are fringed with coolabah (*Eucalyptus microtheca*), river red gum (*Eucalyptus camaldulensis*) and gidgee (*Acacia cambagei*), with black box (*Eucalyptus largiflorens*), river cooba (*Acacia stenophylla*), prickly wattle (*Acacia victoriae*) and thorny saltbush (*Rhagodia spinescens*) occurring in floodouts.

The grey clays of the Bulloo carry canegrass (*Eragrostis australasica*), with lignum (*Muehlenbeckia cunninghammii*) and some black box on the edges of the lunettes. Sand plains support sparse mulga, whitewood (*Aytalaya hemiglauca*), isolated desert poplar (*Codonocarpus cotonifolius*) and western bloodwood (*Eucalyptus terminalis*), as well as patches of woody shrubs and occasional old man saltbush (*Atriplex nummularia*).

7.2 Significant flora

Sturt National Park, in the northwest corner of NSW and the northwestern extent of the Channel Country bioregion is home to several species listed under the TSC Act 1995.

One such species is the vulnerable flame spider-flower (*Grevillea kennedyana*). Most of the known populations of the flame spider-flower are present in the "Jump-Up" region in Sturt National Park and the Channel Country bioregion. The species is listed as vulnerable under Schedule 1, part 2 of the Commonwealth EPBC Act 1999 and as vulnerable under Schedule 2 of the TSC Act 1995.

The rare plants *Ruppia tuberosa* and *Lepilaena preissii* have been recorded at the Clifton Downs Lakes, with the only other known location of these plants in NSW at the Salt Lake in the nearby Simpson-Strzelecki Dunefields Bioregion (J. Porter, pers. comm.). Threatened species predicted to occur in the area include desert carpet-weed (*Glinus orygiodes*), a perennial herb recorded in saline areas; saltbush (*Atriplex sturtii*), an annual recorded from claypans and alluvial plains; *Dysphania platycarpa*, an annual herb that grows near ephemeral waters; and *Stackhousia clementii*, a perennial herb that can be found on ephemeral swamp margins, clay and saline soils.

7.3 Significant fauna

Fauna surveys in the Channel Country Bioregion have reported at least 34 native mammal, 231 bird, 22 amphibian, 13 fish and 125 reptile species (Sattler and Williams 1999).

Several species are endemic to the region. Reptiles endemic to the region include the Cooper Creek tortoise (*Emydura* sp.), skinks (*Ctenotus astarte* and *C. aphrodite*) and an unidentified blind snake (*Ramphotyphlops* sp.). The

Photo: NPWS

Elizabeth Springs goby fish (*Chlamydogobius* sp.) is endemic to Elizabeth Springs in the Diamantina catchment (Morton *et al.* 1995).

At least 7 mammal species have become extinct from the bioregion. These include the desert rat-kangaroo (*Caloprymnus campestris*), western quoll (*Dasyurus geoffroii geoffroii*), golden bandicoot (*Isoodon auratus*), pig-footed bandicoot (*Chaeropus ecaudatus*), lesser bilby (*Macrotis leucura*), burrowing bettong (*Bettongia lesueur*) and the crescent nailtail wallaby (*Onychogalea lunata*) (Australian Terrestrial Biodiversity Assessment 2002).

The birds of the Channel Country Bioregion are typical of those found elsewhere in the semi-arid zone of NSW. The bioregion has significant waterbird populations such as the Australian spotted crake (*Porzana fluminea*), pink-eared duck (*Malacorhynchus membranaceus*), and inland dotterel (*Peltohyas australis*). The bioregion supports one endemic species, the Bulloo sub-species of the grey grasswren (*Amytornis barbartus barbartus*), which inhabits the lignum and cane grass swamps along the Diamantina and Bulloo Rivers. Other threatened and limited range species, such as the Eyrean grasswren (*Amytornis gorderi*) and chestnut-breasted whiteface (*Aphelocephala pectoralis*), occur on the fringes of the bioregion. Some types of birds such as grassland birds and freshwater birds, which have declined in other bioregions across the country, have remained stable in the Channel Country Bioregion and there has been a trend towards an increase in the numbers of granivorous birds (Australian Terrestrial Biodiversity Assessment 2002).

The adoption of reduced, conservative grazing rates in key habitats across the bioregion, particularly in the Bulloo Overflow, needs to be considered if bird diversity in the bioregion is to be preserved. The maintenance of natural flow regimes will also help to protect the diversity of waterbirds.

7.4 Significant wetlands

Both the Bulloo Overflow – Carypundy Swamp and Salisbury Lake, also known as Lake Altibouka, are nationally significant wetlands (ANCA 1996) and are considered to be in good condition in the bioregion. Both these areas are, however, affected by weeds and feral animals.

The Bulloo Overflow – Carypundy Swamp is the terminal basin of an entire inland system of wetlands and is considered to be significant because it is representative of this type of terminal drainage basin and supports large numbers of waterbirds including the freckled duck (*Stictonetta naevosa*) when flooded. The lake is initially freshwater but becomes saline as water evaporates.

Salisbury Lake (Lake Altibouka) is a saltwater lake which is regularly flooded and supports large numbers and a high diversity of waterbirds such as the brolga (*Grus rubicundus*), blue-billed duck (*Oxyura australis*) and freckled duck (*Stictonetta naevosa*). Part of this wetland falls in a wildlife refuge.

Three other wetlands of regional significance occur in the Channel Country Bioregion. These wetlands are considered to be in good condition, although affected to varying degrees by weeds such as Noogoora Burr (*Xanthium occidentale*) and Heliotrope (*Heliotropium peruviana*), and feral animals such as pigs, goats, foxes and cats.

Bullea Lake is an important nesting habitat for waterbirds. The lake has been known to support more than 15,000 waterbirds (Australian Terrestrial Biodiversity Assessment 2002), including the Eurasian coot (*Fulica atra*), pink-eared duck (*Malacorhynchus membranaceus*), grey teal (*Anas gracilis*) and maned duck (*Chenonetta jubata*). The black swan (*Cygnus atratus*), straw-necked ibis (*Threskiornis spinicollis*), great cormorant (*Phalacrocorax carbo*), yellow-billed spoonbill (*Platalea flavipes*) and purple swamphen (*Porphyrio porphyrio*) have also been recorded.

Clifton Downs Lakes consist of two lakes on the "Clifton Downs" property. The great egret (*Ardea alba*), caspian tern (*Hydroprogne caspia*), greenshank (*Tringa nebularia*) and sharp-tailed sandpiper (*Calidris acuminata*), all of which are internationally protected under the China Australia Migratory Bird Agreement (CAMBA), have been recorded on Clifton Downs.

Yantara Lake has recorded sightings of the endangered flock bronzewing (*Phaps histrionica*) and the vulnerable freckled duck (*Stictonetta naevosa*) in 1985 (NPWS 2001). In addition to this, Kingsford *et al.* (1994) sighted about 40 freckled duck (*Stictonetta naevosa*) on the lake in March 1993.

8. Regional history

8.1 Aboriginal occupation

The Karenggapa people traditionally occupied the far northwest corner of NSW at the Qld border (HO and DUAP 1996).

For further information on the Aboriginal occupation of the Channel Country Bioregion, refer to Chapter 1 under the heading "Regional history".

8.2 European occupation

Charles Sturt reached the Darling River near Bourke in 1829 but did not venture further west until 1844-45 when his expedition became trapped near Milparinka from February to July 1845 due to drought (NSW NPWS 1991). James Poole, a member of the expedition, died there and was buried near Mt Poole, just northwest of Milparinka.

Sturt's problems with drought did not discourage squatters from settling along the Darling River between 1847-1857. Pastoralists had ventured into the bioregion by 1878, taking up huge runs in order to support their sheep and cattle (NSW NPWS 1991). Most of this land was occupied under pastoral leases during the 1880s and although overstocking occurred across the far west, droughts at the turn of the century tended to reduce grazing capacities in the area (NSW NPWS 1991). Dingoes proved to be a problem for pastoralists as they, along with the droughts, reduced sheep numbers until dingo fences were built and a strategic hunting program was undertaken (NSW NPWS 1991).

Gold was discovered at Mt Poole and Mt Brown near Milparinka in 1880, stimulating a short period of mining success in the area, and by 1890 the population of the area was large enough to warrant the publication of a local newspaper, the *Milparinka Advertiser* (NSW NPWS 1991).

Tibooburra, like many other towns far removed from the major rivers, owes its existence to mineral discovery (HO and DUAP 1996). Three mineral deposits are currently being mined, or will potentially be mined in the bioregion (CSIRO 1996).

Sir Sidney Kidman was one of the great pastoralists of the far northwest corner of NSW. He worked on several stations in the 1870s and 1880s and learnt the ways of the land, often with the aid of a local Aborigine (NSW NPWS 1991). Kidman was successful in his attempts to connect Tibooburra with towns along the Darling and Gipps Station (what was to become Broken Hill) via supply routes. Cobb and Co. coaches (NSW NPWS 1991) linked Milparinka to Wilcannia in 1883.

Throughout the bioregion, including the interstate components, an average of 0.15 head of cattle is grazed per ha, and 0% is affected by intensive production (CSIRO 1996).

There is no commercial forestry of State forests tenure in the bioregion.

9. Bioregional-scale conservation

The area of the Channel Country Bioregion under conservation management is about 272,949 ha or 19.09% of the bioregion. With only 3 of the 23 available mechanisms deployed, the range being applied to land management is relatively small.

As with most bioregions, national parks and nature reserves include the largest area of land in conservation-oriented management. Sturt National Park, which extends to the adjacent Simpson-Strzelecki Dunefields Bioregion, is the only national park in the bioregion, occupying 189,044 ha or 13.22% of its area. None of these reserves is also managed as wilderness areas under the Wilderness Act 1987.

Most of the Pindera Downs Aboriginal Area occurs in the bioregion and occupies 0.66% of its area. There are no historic sites, no state recreation areas and no regional parks in the bioregion. There are also no voluntary conservation agreements in the Channel Country Bioregion. There are however, 3 wildlife refuges on properties occupying 74,518 ha or 5.21% of the bioregion.

No property agreements (Native Vegetation Act 1997) have been entered into with landholders in the bioregion.

There are no flora reserves or State forests (Forestry Act 1916) in the bioregion.

10. Subregions of the Channel Country Bioregion

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Bulloo	Quaternary clays and sands of the Bulloo River floodout.	Channels and floodplains, clay playas with beaches and lunettes, marginal sandplains and dunes.	Saline cracking grey clays. Siliceous sands on dunes, more complex but poorly known loams and sands on lunettes.	Canegrass and ephemerals on clays. Canegrass, lignum with some black box on lake margins. Sparse mulga, whitewood and old man saltbush on sands.
Core Ranges	Pre-Cambrian and Cambrian schist, slate and volcanics intruded by Devonian granodiorite. Fringing Jurassic sandstones.	Low ranges and rounded hills. Strong control by geology, prominent rounded tors on the granodiorite. Low angle stony slopes and dendritic drainage.	Shallow stony profiles on ranges, contour banded and gibber covered lower slopes.	Open bluebush with sandalwood, dead finish, western pittosporum, copperburr and sparse mulga.
Tibooburra Downs	Cretaceous claystones and Cretaceous sandstones capped by Tertiary silcrete. Quaternary slope mantles and alluvium.	Undulating plains with defined creek lines extending to floodouts. Plateaus, tablelands and mesas with prominent low scarps of silicified rock. Low colluvial slopes to floodout areas.	Deep brown loamy clays and sticky grey green clays, some texture contrast soils. Brown and grey clays in alluvium. Stony, contour banded lower slopes. Brown clays and texture contrast soils in alluvium.	Mitchell grass and forbs in good seasons. Often bare coolabah, river red gum, gidgee, black box, river cooba and chenopods along creeks and in floodouts. Sparse mulga, gidgee and belah with bluebush and saltbush on tablelands. Mitchell grass on slopes. Floodouts similar to Central Downs.

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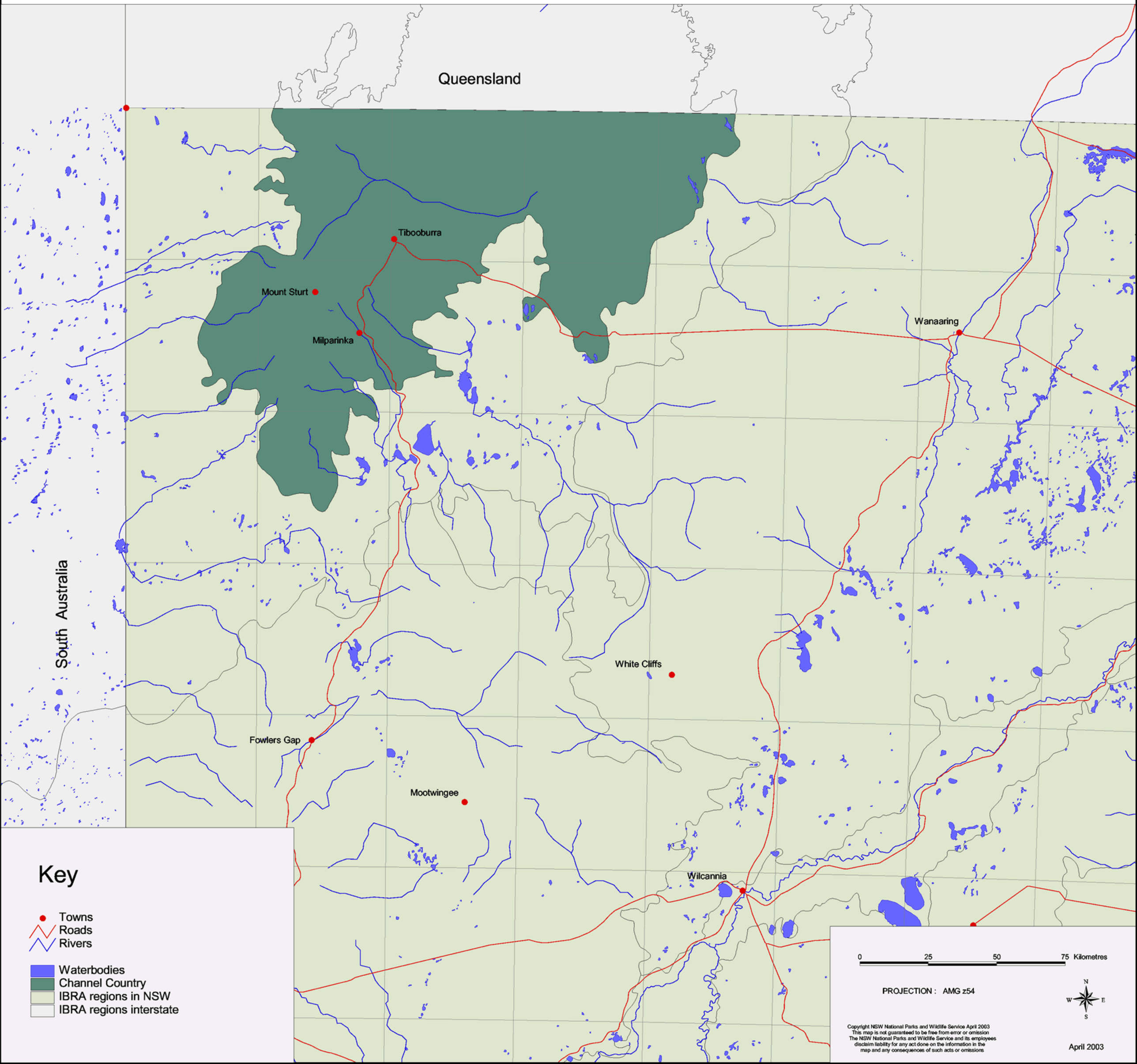
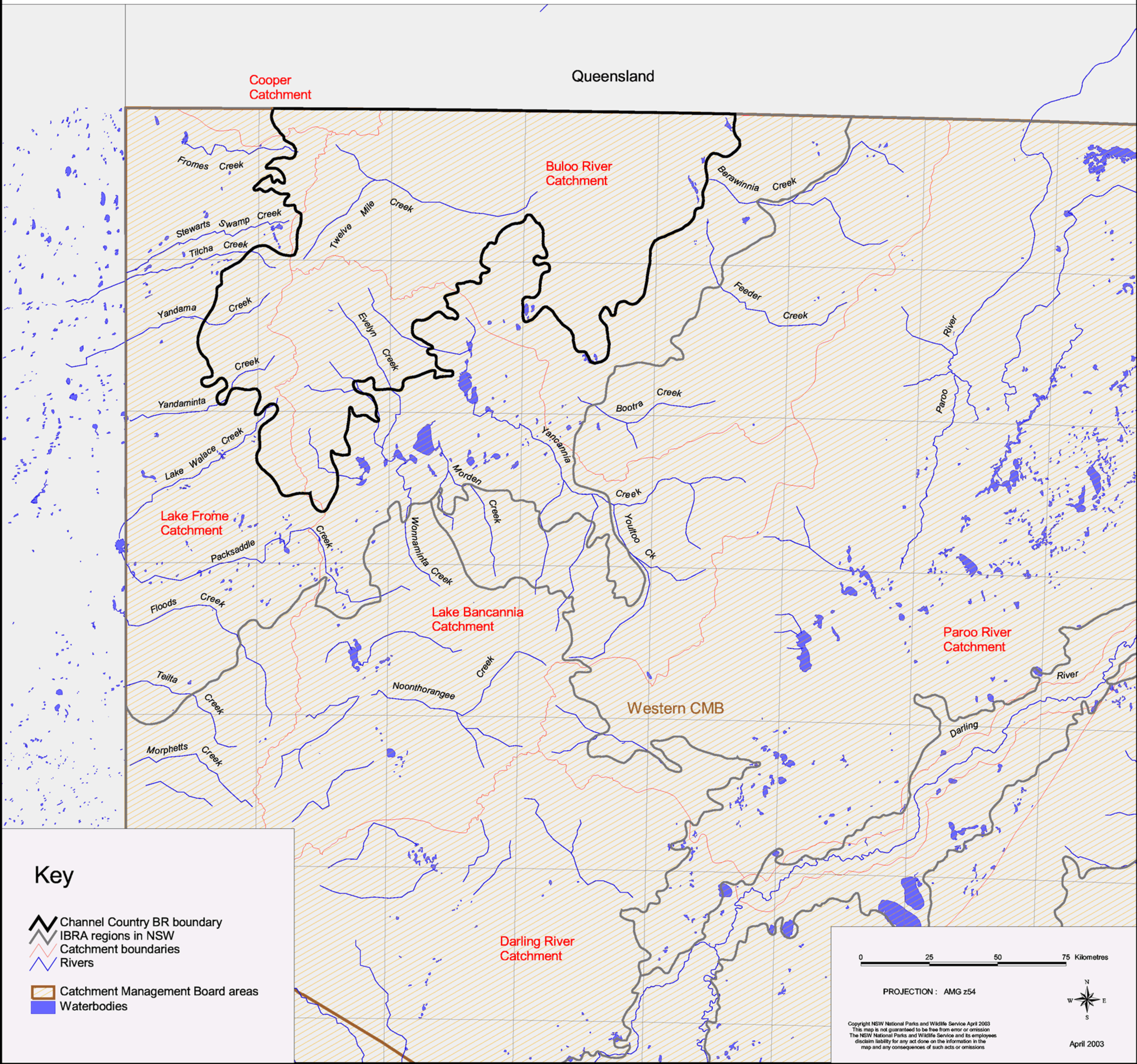
Channel Country Biogeographic Region (IBRA) - Location



April 2003

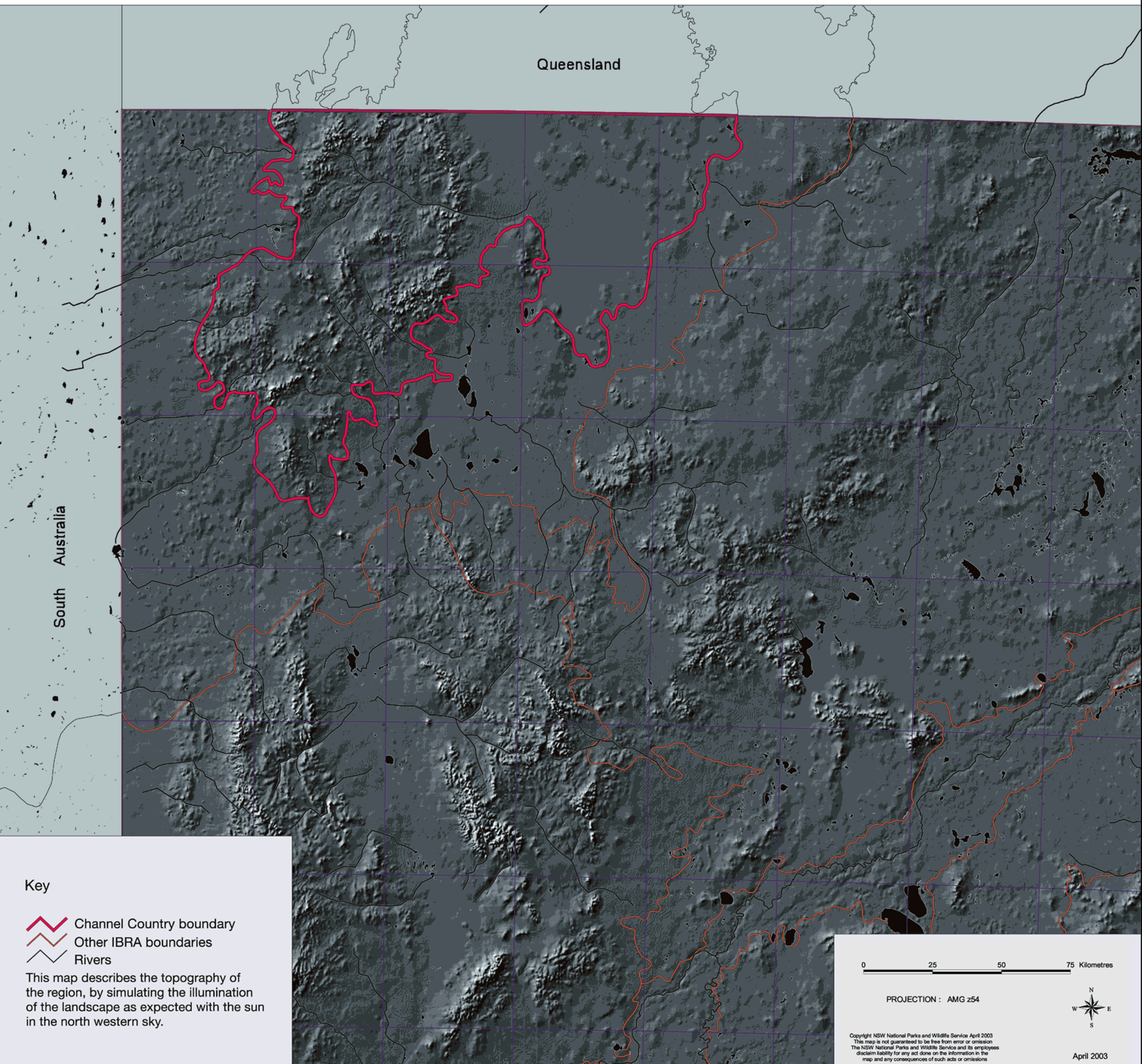
Channel Country Biogeographic Region (IBRA) - Rivers



Key

- Channel Country BR boundary
- IBRA regions in NSW
- Catchment boundaries
- Rivers
- Catchment Management Board areas
- Waterbodies

Channel Country Biogeographic Region (IBRA) - Topography



Key

Channel Country boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

0 25 50 75 Kilometres

PROJECTION : AMG z54

N
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April 2003

Channel Country Biogeographic Region (IBRA) - Vegetation

Queensland

South Australia

Key

- Channel Country BR boundary
- Roads
- Rivers

- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

0 25 50 75 Kilometres

PROJECTION : AMG z54

N W E S

April 2003

Channel Country Biogeographic Region (IBRA) - Tenure/Reserves

Queensland

South Australia

Key

- Channel Country BR boundary
- IBRA regions in NSW
- Roads
- Rivers
- Waterbodies

Wilderness (declared)
- Service Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

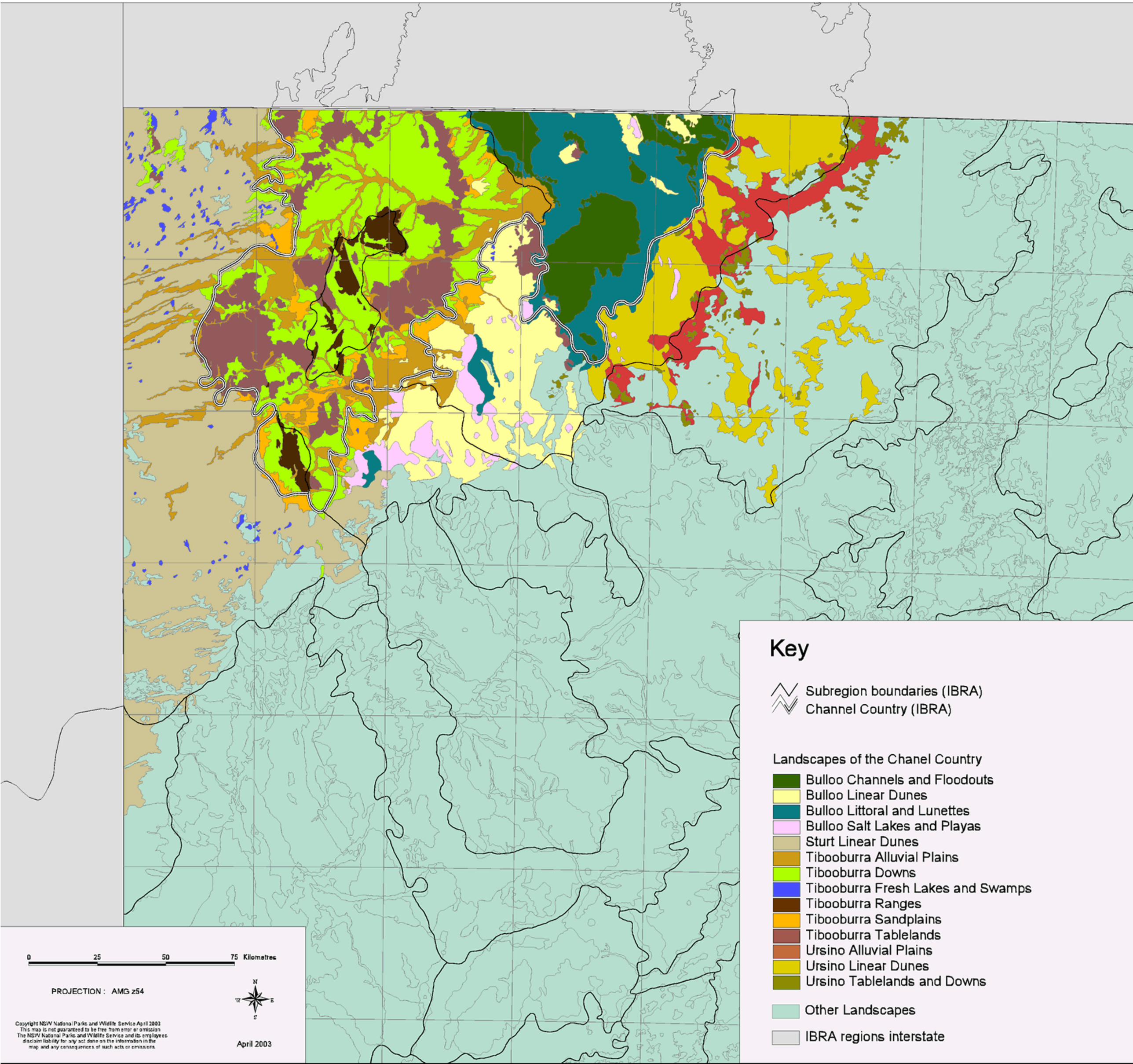
0 25 50 75 Kilometres

PROJECTION : AMG z54

N W E S

April 2003

Channel Country Biogeographic Region (IBRA) - Subregions and Landscapes (Mitchell, in preparation)



CHAPTER 4

The Broken Hill Complex Bioregion

1. Location

The Broken Hill Complex Bioregion lies in the far west of NSW, spanning the NSW-SA border. Across these two states the bioregion has an area of 5,691,042 ha, with 3,811,697 ha or 66.98% falling in NSW. The bioregion occupies about 4.8% of NSW and is bounded by the Murray-Darling Depression and Darling Riverine Plains bioregions in the south, and the Simpson-Strzelecki Dunefields and Mulga Lands bioregions in the north and east respectively. In SA it is bounded by another four bioregions.

The biggest city in the bioregion is Broken Hill with a population of about 20,096 (2001 Census – Australian Bureau of Statistics). There are few other towns in the bioregion. Nearby Silverton was once the main township in the 1880s at the peak of mining activity, but it was soon overshadowed by the faster-growing Broken Hill (HO and DUAP 1996). The entire NSW portion of the bioregion lies within the Western Division.

The eastern part of the Broken Hill Complex Bioregion falls in the Murray-Darling Basin while the Darling River flows just outside the southeastern boundary of the bioregion. The bioregion includes parts of the Lake Frome, Lake Victoria, Lake Bancannia, Paroo and Darling River catchments.

2. Climate

The Broken Hill Complex Bioregion generally has a hot, dry climate and lies within the NSW arid zone. The bioregion is one of four bioregions, all in the far west of the state, that are dominated by a hot, persistently dry desert climate (Stern *et al.* 2000). Patches of semi-arid climate in the centre of the bioregion complement the arid climate prevalent in most of the bioregion.

3. Topography

The Broken Hill Complex Bioregion in western NSW is geologically unique in the state. The western half is composed of ancient basement rocks of the Adelaide Fold Belt, and the eastern half is the edge of the much younger rocks of the Tasman Fold Belt. Many of the rocks and minerals found in the region are of considerable interest and economic importance, and geology exerts strong controls on the landscape.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
17 – 20°C	3.8 – 5.5°C	32.1 – 35.8°C	137 – 257mm	6 – 19mm	16 – 39mm

4. Geology and geomorphology

The Barrier Ranges are a triangular block of metamorphic and deformed sedimentary rocks forming a series of northeast and northwest trending ridges rising up to 300 m above the surrounding plains. Bedrock includes schist and gneiss, intrusive granites, amphibolites and very coarse pegmatites. Some of these rocks contain inherited minerals up to 2,600 million years old and the whole sequence was once part of the land mass of Rodinia that included parts of present-day North America and China.

Basement rocks are partly overlain by Cambrian and Devonian conglomerates, quartz sandstones, shales and thin beds of limestone. Scopes, Mootwingee and Wonnaminta Ranges are mainly Ordovician to Devonian conglomerates – sandstones and shales that have been only gently folded. On the eastern margin of the Mootwingee and Wonnaminta Ranges, horizontally bedded sandstones of Cretaceous age form flat-topped mesas and tablelands that extend northeast into the Mulga Lands Bioregion.

The geomorphology of the ranges is controlled by the different rock types and their structure. Faults up to 60 km long form prominent scarps between hill country and plains. Hard rocks outcrop as strike ridges and remnant pinnacles standing above long shallow slopes, with thin soils developed on the softer rocks. These rock cut slopes pass to wide footslopes and alluvial plains. Hills on granite are more rounded and subdued. Limestone and dolomites occur in limited areas as linear outcrops.

Streams have cut steep-sided gorges containing sheltered waterholes through the ranges. Beyond the footslopes the streams expand as alluvial fans, distributing sediment into sandy floodouts and clay playas. Much of the drainage from the Barrier, Mootwingee and Wonnaminta ranges ends in the Bancannia trough, where shallow lakes and swamps have formed and alluvial sand has been blown into sandplains and dune fields.

5. Geodiversity

Important features include the following:

- prominent landscapes such as the Mundi Mundi, Nundooka and Koonenberry fault scarps and adjacent plains, the Pinnacles, and the dip-slope escarpments and deep gorges of the Mootwingee Range;
- the region contains more than 2,000 mineral locations, the most famous being the Broken Hill main lode, one of the world's largest silver, lead and zinc deposits. Sites include the remnants of the Broken Hill ore body and its mining history; silver deposits and mining history at Thackaringa; tin mines at Euriowie; and numerous rare rock types and mineral deposits such as the Triple Chance and Egebek pegmatites;
- other heritage features are associated with particular geological features. The best examples are the important Aboriginal sites at Mootwingee, Sturts Meadows and Euriowie, where occupation was facilitated by water holes in protected gorges, and Aboriginal rock engravings have been made on selected sandstone faces;
- In 1845 Charles Sturt erected a stone cairn on the top of Mt Poole when trapped by drought at Depot Glen. The boulders gathered from the mountain top are quartzite and silcrete that had also been used for thousands of years by Aboriginal people as raw material for artefacts.

Smaller features of note include:

- contour banding of soils and vegetation on the stony downs country;
- giant desiccation polygons on the plains south of Topar; and
- palaeo-drainage patterns of lakes and former streams between Mootwingee and the Barrier Ranges.

Photo: Caroline Boyd

6. Soils

Rock-weathering processes have been operating continuously in the region for more than 90 million years and a deep weathered mantle has formed across most of the landscape. Many slopes are mantled by gibber (rounded, silica-rich boulders) derived from the breakdown of silicified sediments (silcrete duricrusts).

Soils vary with parent materials. Shallow, stony soils are found between outcrops in the ranges where the runoff from rock surfaces is important in maintaining plants and animals through drought. Stony desert pavements are widespread and often form contoured patterns of soil and vegetation in downs country. Soils in the depositional basin are deep red sands with uniform sandy profiles under dunes, and gradational profiles in the sandplains. Most soils have a moderate to high level of calcium carbonate in the profile. Heavy cracking clays in floodouts and on lake beds are often unvegetated because they contain high levels of gypsum and sometimes salt. Abandoned shorelines and low lunettes attached to the eastern side of playas and lakes such as Lake Bancannia provide evidence of climate change over the past 30,000 to 100,000 years.

7. Biodiversity

7.1 Plant communities

Mulga (*Acacia aneura*) communities coupled with chenopod shrubland composed of saltbush and bluebush communities (Benson 1999) characterise the vegetation of the bioregion (Morgan and Terrey 1992). Belah (*Casuarina cristata*), rosewood (*Alectryon oleifolius*), white cypress pine (*Callitris glaucophylla*) and mallee communities also occur throughout the bioregion (Benson 1999). Most plants are very sensitive to available soil moisture and runoff patterns largely control vegetation distribution.

Range crests have sparse vegetation including mulga, dead finish (*Acacia tetragonophylla*) and scattered bluebush (*Maireana* sp.). Vegetation is more abundant and diverse on the deeper loamy soils of the footslopes and valleys, where there is more moisture. Dominant species include belah, rosewood (*Heterodendrum oleifolium*), occasional beefwood (*Grevillea striata*) and leopardwood (*Flindersia maculata*). Bluebush, bladder saltbush (*Atriplex vesicaria*), prickly wattle (*Acacia victoriae*), turpentine (*Eremophila sturtii*), narrow-leaf hopbush (*Dodonaea attenuata*), copperburrs (*Sclerolaena* sp.), variable speargrass (*Stipa variabilis*) and forbs form a discontinuous understorey.

Limestone or dolomite outcrops have shallow, highly calcareous, brown loamy soils with generally sparse vegetation and some rare plant species such as curly mallee (*Eucalyptus gillii*). The tops of mesas and tablelands are usually treeless except for occasional mulga, gidgee, dead finish and *Eremophila* sp., with bladder saltbush, pearl bluebush, copperburrs and annual grasses on the slopes.

Swamps and fresh lakes have a fringing of black box (*Eucalyptus largiflorens*) woodland with cane grass (*Eragrostis australasica*) and copperburrs on the lake bed. Lunettes have brown clayey sand which carry mulga, turpentine (*Eremophila sturtii*) and often pearl bluebush (*Maireana sedifolia*). Larger stream channels support river red gum (*Eucalyptus camaldulensis*), some coolabah (*Eucalyptus microtheca*) and river cooba (*Acacia stenophylla*), with oldman saltbush (*Atriplex nummularia*) and thorny saltbush (*Rhagodia spinescens*) on the banks.

Sandplains and dunes have a varied cover of low trees and shrubs including mulga, nelia (*Acacia loderi*), needlewood (*Hakea leucoptera*), rosewood, clumps of belah, occasional leopardwood, dense patches of punty bush (*Cassia eremophila*), western boobialla (*Myoporum montanum*), emu bush (*Eremophila longifolia*), turpentine, narrow-leaf hopbush, prickly wattle, variable spear grass and copperburr.

7.2 Significant flora

The only occurrence of the mallee species *Eucalyptus gillii* in NSW is in the bioregion in the Barrier Range near Broken Hill (Benson 1999).

Several species are at risk in the bioregion. Listed as vulnerable in the TSC Act, *Acacia carnei* is threatened by rabbits grazing on seedlings (Auld 1993, cited in Morton *et al*. 1995). Bowen and Pressey (1993, cited in Morton *et al*. 1995) also reported *Lepidium monoplocoides* and *Eleocharis obicis* and *Rhaphidospora bonneyana*, which are both listed as Vulnerable under the TSC Act.

Several plants in the bioregion are considered to be rare, including *Gahnia lanigera, Paspalidium clementii, Ixiochlamys nana, Pluchea baccharoides, Vittadinia arida, Atriplex lobativalvis, A. morrisii, Euphorbia sarcostemmoides* and *Goodenia berardiana* (Bowen and Pressey 1993, cited in Morton *et al*. 1995).

7.3 Significant fauna

A total of 195 species of birds, 58 species of reptiles, 5 species of amphibians and 37 species of mammals have been recorded in the Broken Hill Complex Bioregion (National Land and Water Resources Audit website – http://www.nlwra.gov.au/).

In this bioregion, the endangered yellow-footed rock-wallaby (*Petrogale xanthopus*) has a limited distribution centred on the Bynguano and Coturaundee Ranges between Mootwingee and White Cliffs, north of Broken Hill (Lim *et al*. 1987, Lim and Giles 1989, cited in Morton *et al*. 1995). Since European settlement, the species has undergone dramatic decline, with several populations becoming extinct in the early 1900s. In NSW, the species consists of only one population of about 100 individuals living in two colonies in Mootwingee National Park and Coturaundee Nature Reserve.

The endangered Bolam's mouse (*Pseudomys bolami*) is a native rodent known from the mallee shrublands of the Broken Hill Complex and Murray Darling Depression bioregions. This species is nocturnal, spending its days sheltering in burrows while at night it is active, feeding on seeds, fruits, blossoms, grasses, herbs and insects.

Populations of letter-winged kites (*Elanus scriptus*), black-breasted buzzards (*Hamirostra melanosternon*), Australian bustards (*Ardeotis kori*), bush thick-knees (or bush stone-curlew) (*Burhinus grallarius)* and Bourke's parrots (*Neophema bourkii*) have been recorded in the bioregion and are considered to be at risk (Smith and Smith 1994; cited in Morton et al, 1995). Populations of bush stone-curlew are also known from other bioregions in NSW but have not been recorded in the Broken Hill Complex Bioregion since the 1980s (NSW NPWS 1999a). As with other areas of western NSW, birds of the chenopod shrublands in the bioregion seem to be at risk of decline (Reid and Fleming 1992, cited in Morton *et al*. 1995).

The birds of the Broken Hill Complex Bioregion are fairly typical of those found elsewhere in the semi-arid zone of NSW. The diversity of birds in the bioregion is comparatively low but there are species with limited ranges, such as the chirruping wedgebill (*Psopohdes cristatus*), that occur here.

Both ground-nesting birds and ground-feeding insectivores have undergone a serious decline in their numbers in this bioregion. This can be partly attributed to grazing of extensive areas of habitat. Continued loss of ground-feeding insectivores is likely to continue unless the problem can be addressed by reduction of grazing pressure in suitable areas and protection of adequate habitat.

The agamid, or dragon lizard (*Ctenophorus decresii*), is reasonably restricted nationally, and in NSW is confined to several isolated sites in the Barrier Range. The skink (*Ctenotus uber*) is represented in NSW by a distinct specimen known only from five sites (Sadlier and Pressey 1994; cited in Morton *et al*. 1995).

7.4 Significant wetlands

Part of the Menindee Lakes system falls in the bioregion. This wetland is of national significance and is located along the Darling River in the Barrier Range Outwash Fans and Plains subregion. The Menindee Lakes system is managed for water storage for supply to South Australia. Poor timing of inflow and outflow can result in habitat loss during breeding times and demand for irrigation water can exceed supply, leading to rapid depletion of residual pools during drought. Grazing occurs in the vicinity of the wetland, but is becoming more conservatively managed. Weed species and feral animals, including rabbits, pigs, goats, foxes and cats, all present a threat to the biodiversity of the wetland.

Two other wetlands in the bioregion are identified as having subregional significance. Bancannia Lake, an intermittent freshwater lake located in the Barrier Range Outwash Fans and Plains subregion, is described as being in good condition. It is an important aggregation site for fauna, supporting many waterbird species including the vulnerable freckled duck (*Stictonetta naevosa*), with sightings of the blue-billed duck (*Oxyura australis*). Grazing, feral animals and weed invasion all pose threats to this wetland.

Stephens Creek Reservoir in the Barrier Range subregion is a water-storage area. Sightings of rare fauna at the reservoir include the vulnerable blue-billed duck and the little pied bat (*Chalinolobus picatus*). The freckled duck and redthroat (*Pyrrholaemus brunneus*) have also been sighted. Cats are considered to be the greatest threat to the biodiversity of the wetland.

8. Regional history

8.1 Aboriginal occupation

The Wiljakali people traditionally occupied the lands around Broken Hill (HO and DUAP 1996) visiting the Barkindji people on the Menindee Lakes each year.

For further information on Aboriginal occupation of the Broken Hill Complex Bioregion, refer to Chapter 1 under the heading "Regional history".

8.2 European occupation

Charles Sturt named the Barrier Range which impeded his progress when he explored the area near Broken Hill in 1844-45, referring to a "broken hill" in his diary (HO and DUAP 1996). (www.walkabout.com.au/fairfax/locations/NSWBrokenHill.shtml) Edward Giles explored the Mootwingee area in 1861 and 1863 (NSW NPWS 1991).

Broken Hill, like other towns in western NSW, is far removed from major rivers and owes its existence to the discovery of mineral resources (HO and DUAP 1996). Gold was first discovered in the Barrier Ranges in the 1860s, although the key period of lucrative exploration for gold, silver, tin and lead did not really begin until 1875, and lasted about 10 years (HO and DUAP 1996). The first find in this critical period of mining history occurred during the sinking of a well at Thackaringa pastoral station in 1875 (NSW NPWS 1991), less than 40 km west of Broken Hill. The expense of transporting and processing the ore turned interest towards more lucrative gold discoveries further north in the Channel Country Bioregion, although some mining continued in the Broken Hill area (HO and DUAP 1996). The early 1880s saw many hopeful finds of silver to the northwest of Broken Hill at Silverton and Umberumberka. Silverton had a population of 250 by September 1883, a number which doubled by December the same year and reached 1,700 a year later. Silverton had a reputation for harbouring various undesirables in the form of "horse stealers, cattle duffers and mining sharks" (NSW NPWS 1991).

In 1883, Charles Rasp collected samples of what he thought was tin and although these turned out to be from rich lodes of silver and lead, it was almost two years before the ore body was discovered to be the largest and richest of its kind in the world. The "syndicate of seven", led by Rasp, were leaseholders at Mount Gipps, the site of this discovery in 1883. The following year they became the "company of fourteen" and by 1885 had formed Broken Hill Proprietary Company, now known as BHP (Department of Mineral Resources website – http://www.minerals.nsw.gov.au/).

Due to these developments, Broken Hill began to dominate the bioregion from 1885 as a major township (HO and DUAP 1996). Its growth was aided by the newly discovered lodes and the creation of the Silverton Tramway Company which provided a link from Broken Hill to the new mines and the South Australian border. By 1891 the population of Broken Hill had exploded to 20,000 and it became the third largest metropolis in NSW, although it retained its strong ties with South Australia (HO and DUAP 1996). With the growth of Broken Hill, the population of Silverton began to decline and its status as a municipality was removed in 1907, the same year that Broken Hill was declared a municipality (HO and DUAP 1996). Several new mines developed in the 1920s, ensuring the continued growth of Broken Hill.

As it was some distance from the nearest major river, the water supply in the Broken Hill area had to be transported by the Silverton train from 1888. In 1889, the tramway from Menindee to Broken Hill was used to transport water from the Darling River (NSW NPWS 1991). Water continued to be carted to Broken Hill until after World War II when a pipeline from the Menindee Lakes to Broken Hill underwent construction, and by 1952 it serviced not only Broken Hill but agriculture on the Darling as well (NSW NPWS 1991). A railway line from Sydney reached Broken Hill in 1927.

The population of Broken Hill grew to 27,000 in the early 1900s, remaining at this level through the 1920s and 1930s and reaching 30,000 in the 1960s (HO and DUAP 1996).

Broken Hill's population was recorded as 20,963 in the 1996 Australian census (http://www.abs.gov.au/). BHP ceased work at Broken Hill in 1940 and there is only one mining operator remaining in Broken Hill today.

Timber was always a naturally scarce resource in the Broken Hill Complex Bioregion, its shortage heightened by the demand for timber to fuel steam trains as well as for structural supports in the mines (NSW NPWS 1991). When most of the local timber was removed in the bioregion, prompting erosion and contributing to serious dust storms, builders and miners brought timber in from Adelaide (NSW NPWS 1991). Irrigation and a protective cultivation zone surrounding the town of Broken Hill have reduced the incidence of dust storms (NSW NPWS 1991).

9. Bioregional-scale conservation

As with many of the NSW bioregions, the Broken Hill Complex Bioregion has a low conservation status in terms of overall area under conservation management, amounting to 96,078 ha or 2.52% of the bioregion. The range of conservation mechanisms deployed is also relatively small. As with most of the bioregions, national parks and nature reserves make the largest contribution in terms of overall area. Mutawinji National Park and Mutawinji Nature Reserve lie wholly in the bioregion and these, together with parts of Kinchega National Park, occupy 79,965 ha or 2.10% of the bioregion. With an area of 47,895 or 1.26% of the bioregion, the Mootwingee Wilderness Area provides additional protection to part of Mutawinji National Park due to its declaration under the Wilderness Act 1987.

Of other possible conservation tenures under the NPW Act 1974, Mutawinji Historic Site occupies 0.02% of the bioregion but there are no Aboriginal areas, no state recreation areas and no regional parks in the bioregion. No voluntary conservation agreements have been entered into by landholders in the Broken Hill Complex Bioregion although wildlife refuges have been established by at least two landholders. These occupy 15,516 ha or 0.41% of the bioregion. Six additional wildlife refuges will soon be added to the bioregion.

No property agreements (NVC Act 1997) have been entered into with landholders in the bioregion.

The bioregion has no land managed under the Forestry Act 1916.

Photo: Caroline Boyd

10. Subregions of the Broken Hill Complex

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Barrier Range Parts of 28 land systems.	Ancient gneiss, schists, amphibolite, granites and pegmatites with north-east structural trends, overlain by Cambrian sediments with northwest trends.	Steep, low rocky ranges oriented to bedrock structure. Prominent fault scarps. Eroded footslopes extend to outwash fans.	A high proportion of rock outcrop with shallow stony soil on the crests. Soils become deeper and finer downslope. Texture contrast profiles are common and quality differs according to rock type.	Limited mulga, dead finish and bluebush on the ridges. Denser shrubs including belah, whitewood, turpentine, prickly wattle, punty bush with bluebush, grasses and forbs on the lower slopes. River red gum line larger creeks, shrubs and grasses increase on the outwash fans. Curly mallee on limestone outcrops.
Mootwingee Downs Parts of 23 land systems.	Ordovician and Devonian conglomerates, sandstones and siltstones with northwest structural trends. Late pre-Cambrian sandstone, chert and schist lies under the rocks of the ranges. Cretaceous sandstones form tabletops on the eastern edge of the subregion.	Asymmetric stony ridges formed by resistant bedrocks, cut by deep gorges and alternating with soil and debris filled valleys. Larger streams deliver sand to the fans and plains. Tablelands and mesas of Cretaceous sandstone in the east and northeast.	Very limited soil on the ranges. Stony sands on the lower slopes extending to deep gravels and sands in the stream lines and floodouts. In situ brown to grey green clayey sands on Cretaceous rocks.	Mulga is common on the hills with white pine and numerous shrubs. River red gum line the creeks. Denser mulga, patches of belah, occasional beefwood, and dense prickly wattle, and other shrubs occur in the valleys. Bluebush and saltbush, with patches of belah and occasional gidgee on the tablelands and slopes.
Scopes Range Parts of 7 land systems.	Ordovician quartz sandstone with northeast trend and low angle dips.	Low rounded hills with a high proportion of rock outcrop. Faulted edge against a cemented gravel apron of Tertiary age on the eastern side.	Shallow stony profiles on crests and slopes extending to sandy outwash fans.	Open mulga, patches of belah and bluebush on the hills. Bluebush and saltbush communities on the slopes extending to grasses and saltbush on the plains. River red gum on the larger creek lines.
Barrier Range Outwash Parts of 23 land systems.	Quaternary colluvial and alluvial slope deposits, floodplain and fan sediments, and aeolian sands.	Stream channels and floodplains, low angle alluvial fans and floodouts, extending to extensive sandplains and dunefields with lakes and claypans. Limited lunette development.	Deep red sands on sandplains and dunes, clayey sands in floodouts extending to dark coloured cracking clays in swamps and lake beds. Brown loamy sands on lunettes.	River red gum and some black box on the larger creek lines. Mulga, belah, rosewood with occasional nelia and leopardwood and an understorey of grasses and bluebush on the sandplains and dunes. Some porcupine grass. Canegrass, chenopods and some lignum on lake beds with fringing black box. Mulga, turpentine and bluebush on lunettes.

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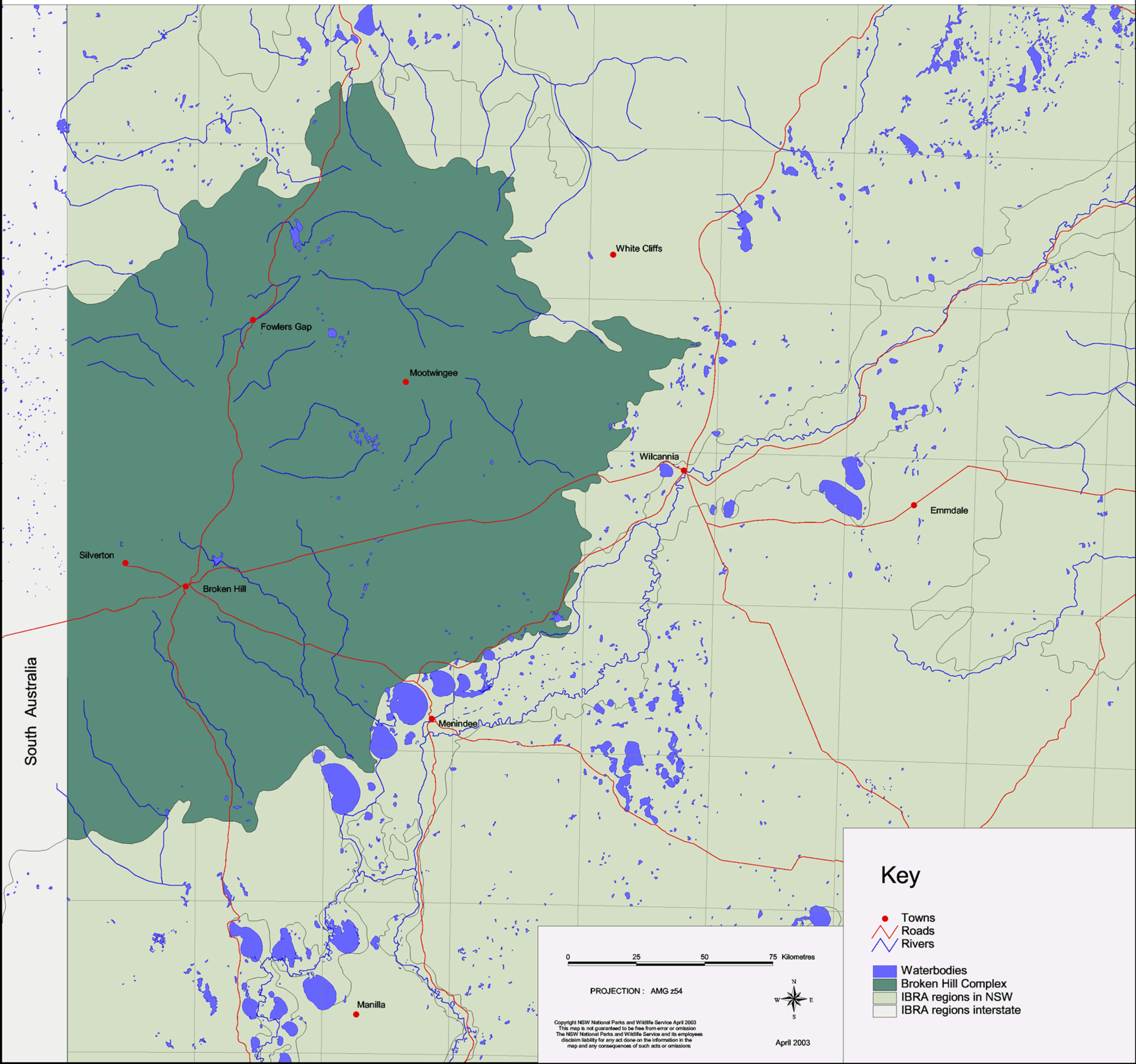
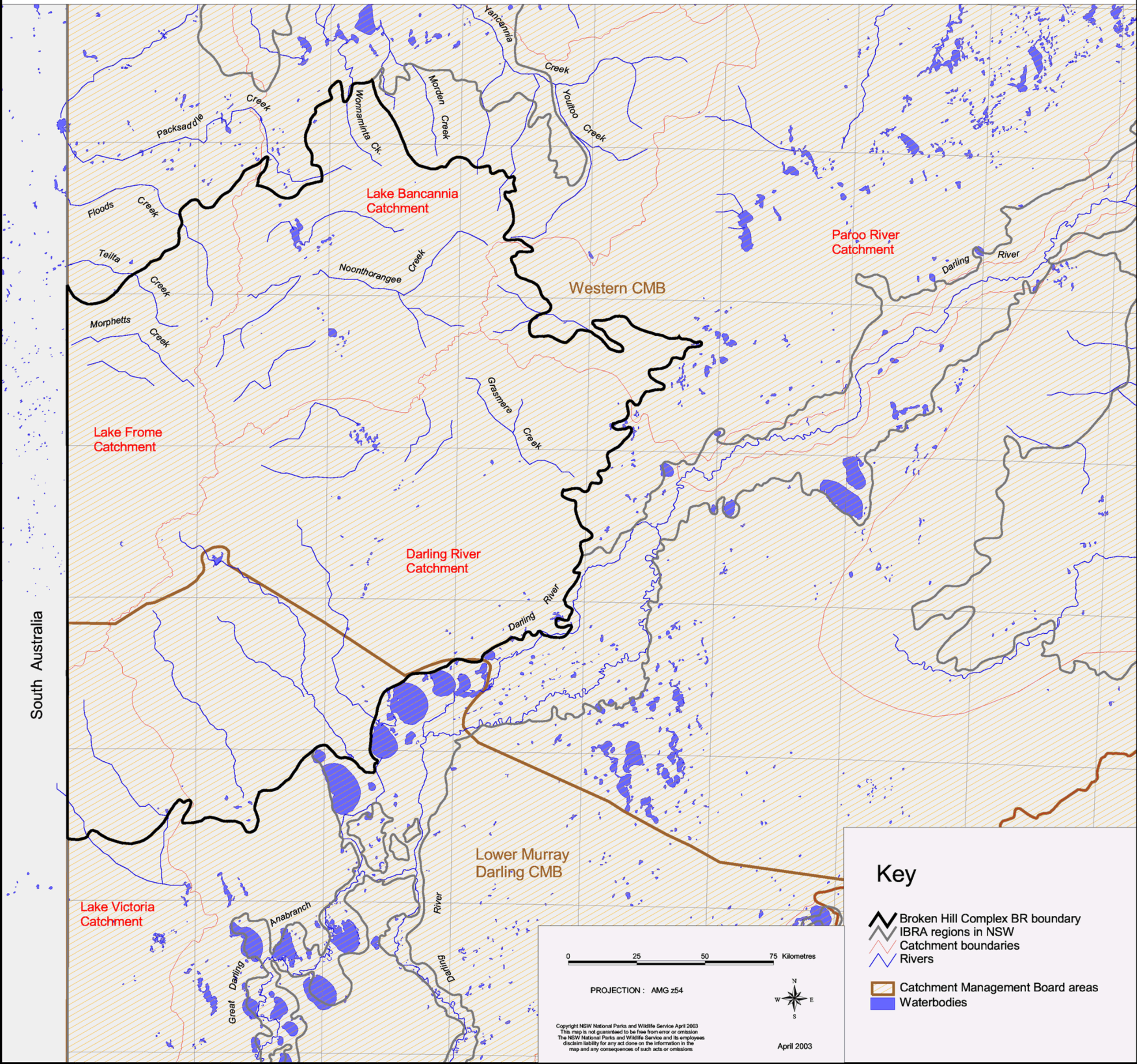
Broken Hill Complex Biogeographic Region (IBRA) - Location



Broken Hill Complex Biogeographic Region (IBRA) - Rivers



Broken Hill Complex Biogeographic Region (IBRA) - Topography

South Australia

0 25 50 75 Kilometres

PROJECTION : AMG z54

N
W E
S

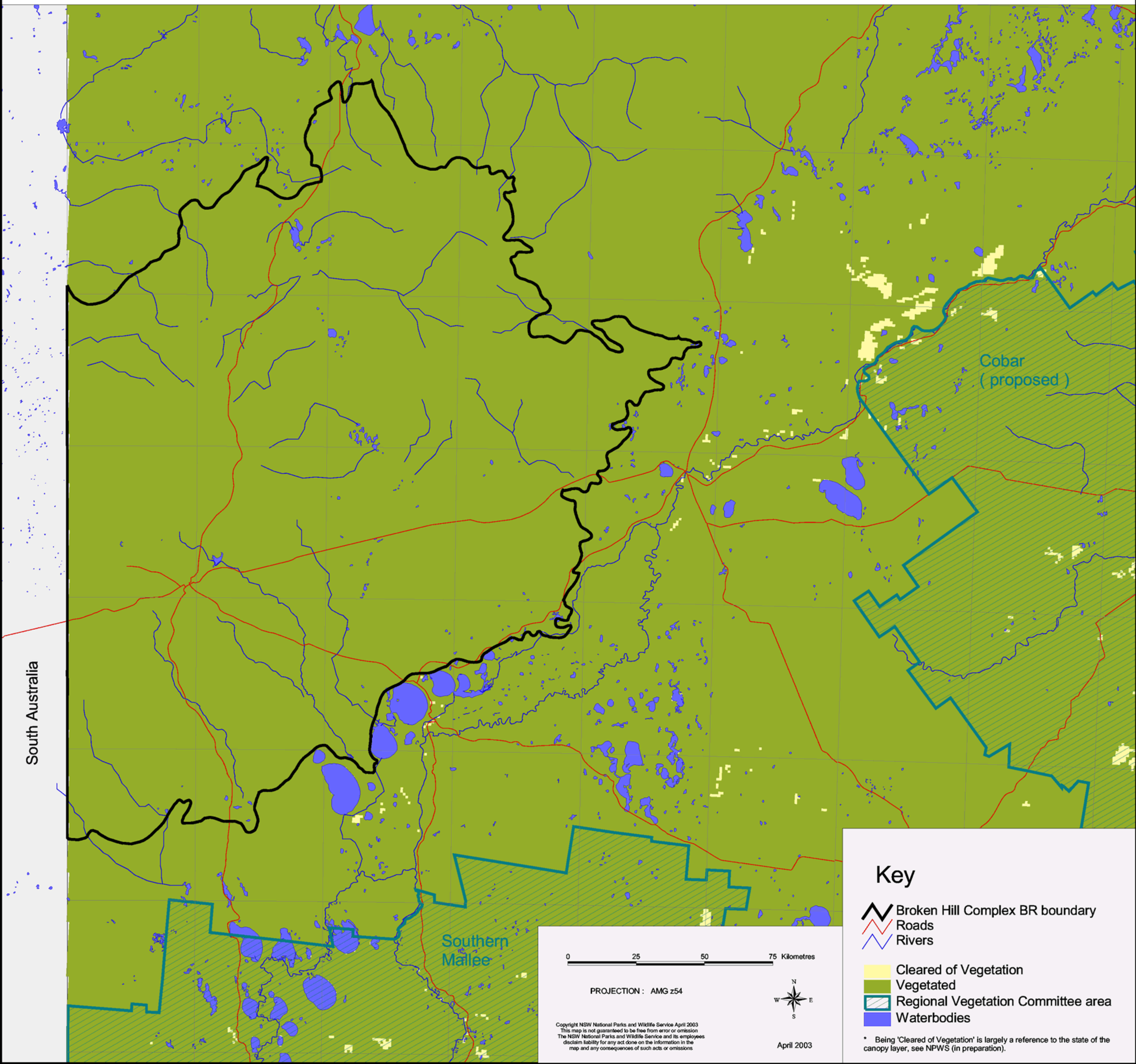
April 2003

Key

Broken Hill Complex boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

Broken Hill Complex Biogeographic Region (IBRA) - Vegetation



Broken Hill Complex Biogeographic Region (IBRA) - Tenure/Reserves

South Australia

Key

- Broken Hill Complex BR boundary
- IBRA regions in NSW
- Roads
- Rivers
- Waterbodies

Wilderness (declared)
- Service Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

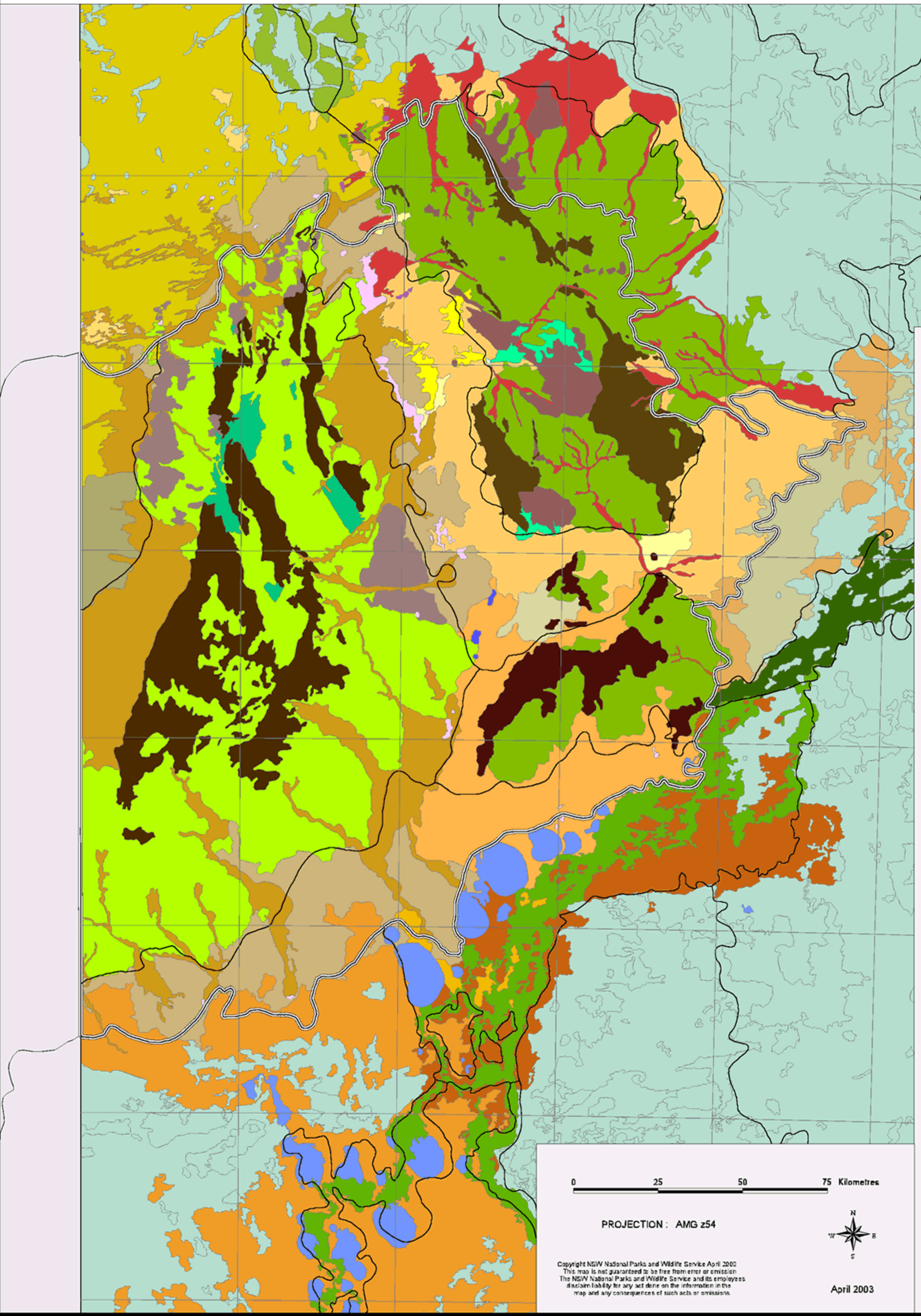
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Broken Hill Complex Biogeographic Region (IBRA) - Subregions and Landscapes (Mitchell, in preparation)



Key

Subregion boundaries (IBRA)

Broken Hill Complex (IBRA)

Landscapes of the Broken Hill Complex

- Barrier Alluvial Plains
- Barrier Downs
- Barrier Fresh Lakes and Swamps
- Barrier Ranges
- Barrier Salt Lakes and Playas
- Barrier Sandplains
- Barrier Tablelands
- Corona Teamsters Limestone
- Lower Darling Alluvial Plains
- Lower Darling Channels and Floodplains
- Lower Darling Lakes and Swamps
- Menindee Sandplains
- Mid Darling Channels and Floodplains
- Mootwingee-Wonnaminta Alluvial Plains
- Mootwingee-Wonnaminta Downs
- Mootwingee-Wonnaminta Dunes
- Mootwingee-Wonnaminta Footslopes
- Mootwingee-Wonnaminta Fresh Lakes
- Mootwingee-Wonnaminta Linear Dunes
- Mootwingee-Wonnaminta Ranges
- Mootwingee-Wonnaminta Salt Lakes and Playas
- Mootwingee-Wonnaminta Sandplains
- Mootwingee-Wonnaminta Tablelands
- Paroo-Warrego Linear Dunes
- Paroo-Warrego Sandplains
- Scopes Alluvial Plains
- Scopes Downs
- Scopes Linear Dunes
- Scopes Ranges
- Scopes Salt Lakes and Playas
- Scopes Sandplains
- Scotia Sandplains
- Sturt Dunes
- Sturt Linear Dunes
- Sturt Sandplains
- Tibooburra Downs

Other Landscapes

IBRA regions interstate

0 25 50 75 Kilometres

PROJECTION : AMG z54

N W E S

April 2003

CHAPTER 5

The Mulga Lands Bioregion

1. Location

The Mulga Lands Bioregion is in northern NSW, extending north and west into Qld. Of a total area of 25,449,547 ha, 25.75% (or 6,554,033 ha) of the bioregion lies in NSW, with the remainder in Qld.

The NSW section of the bioregion is contained wholly in the NSW Western Division and occupies 8.19% of the state. The bioregion is bounded by the Simpson-Strzelecki Dunefields and Broken Hill Complex bioregions in the west and the Darling River in the Darling Riverine Plains Bioregion bounds the Mulga Lands to the south and east. Several small townships are found in the NSW part of the bioregion, including Wanaaring, Enngonia, White Cliffs and Yantabulla, while Hungerford and Barringun lie across the border in Qld.

The Paroo River flows through Wanaaring at the centre of the bioregion, the Warrego River flows through Enngonia to the east, and further east the Culgoa River flows parallel to the northeastern border in the adjacent Darling Riverine Plains Bioregion. The bioregion lies mostly within the Murray-Darling Basin and encompasses the Bulloo, Lake Bancannia, Warrego, Paroo, Darling, Barwon and Culgoa River catchments.

2. Climate

The Mulga Lands Bioregion is dominated by a hot, persistently dry, semi-arid climate in the Warrego catchment. The western part of the bioregion has a more arid, desert climate.

3. Topography

Only a few areas of Palaeozoic bedrock are found in the bioregion, where resistant quartz sandstones emerge from the Cretaceous and Quaternary blankets of sediment. These form low rounded isolated ranges and hills such as Mt Pleasant and could be considered as outliers of the Cobar Peneplain Bioregion.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
10 – 18°C	-3.5 – 3.6°C	22.9 – 34.7°C	556 – 1270mm	31 – 83mm	76 – 137mm

4. Geology and geomorphology

The Mulga Lands Bioregion is dominated by horizontal Cretaceous sandstones and claystones deposited in an inland sea about 100 million years ago. These sediments vary in thickness across the basement rocks and they form the main water-bearing strata of the Great Australian Basin. Artesian mound springs from these aquifers have forced through overlying strata but most are now inactive, an important exception being Perry springs. Many parts of the surface sandstones and more recent sands were silicified during the Tertiary to form silcrete, a tough fine-grained quartzite. These rocks often contain plant fossil remains indicating much wetter environments than occur at present. Silcrete pebbles and boulders mantle the landscape as gibber and massive silcrete often forms the low cliff lines on plateau and tableland margins. The Cretaceous sediments have been gently folded and have small offset faults that are probably important in controlling the distribution of plateaus.

Alluvial fans of the Paroo and Warrego river systems have deposited sands and clays between the plateau areas of sandstones. Under today's rainfall these streams do not often flow into the Darling, and the clay pans toward the end of the fans are often saline, suggesting that groundwater may have an influence on them. Sand has been blown from the alluvial sediments and probably from Cretaceous sandstones to form extensive sandplains with limited areas of dunefield that encroach on the edges of the high ground. Elsewhere, the alluvial systems are dominated by grey and brown cracking clays in channels and claypans. Lakes and swamps are normally dry but all wetland systems are very important ecologically in wet years.

5. Geodiversity

Important features of the bioregion include the following:

- extensive ephemeral wetland systems;
- fans of both the Warrego and Paroo – excellent examples of Quaternary riverine landforms preserved in a semi-arid zone;
- Peery Springs, the last flowing mound spring in the NSW section of the Great Australian Basin;
- Lake Burkanoko and Lake Nichebulka, east of Wanaaring, both good examples of inland hypersaline lakes;
- the Paroo River – the last free-flowing tributary of the Darling, with no water control structures and no catchment cultivation;
- the White Cliffs and Gemville opal fields, the first commercial fields in the world which contain numerous heritage elements associated with mining and are still producing opal; and
- silcrete, which was widely used as a stone tool resource by Aboriginal people, so it is likely that the region contains numerous quarry sites.

6. Soils

The plateau and tablelands typically have shallow, stony, red-brown loams. These merge downslope, often through patterns of contour banding into brown texture contrast soils. Silcrete gibber is widespread as a surface lag gravel. In the sandplain areas, red earths and red siliceous sands are the norm but the colour is not as bright as in the larger dunes of the Simpson-Strzelecki Bioregion. Grey and brown cracking clays dominate the alluvial sequences with limited areas of sand deposition often reworked into source bordering sand sheets or low dunes. Most soils contain calcium carbonate in their sub-soil and clays in the claypans. Lake beds at the far end of the alluvial fans are often saline and contain gypsum.

7. Biodiversity

7.1 Plant communities

As its name suggests, the predominant vegetation of the bioregion is mulga (*Acacia aneura*). The eastern and northern parts of the bioregion support mulga, western bloodwood (*Eucalyptus terminalis*) and poplar box (*Eucalyptus populnea*), with mallee (*Eucalyptus* sp.), white cypress pine (*Callitris glaucophylla*), silver-leaf ironbark (*Eucalyptus melanophloia*), beefwood (*Grevillea striata*), leopardwood (*Flindersia maculosa*) and bluebush (*Maireana* sp.). Spinifex (*Triodia* sp.) is found on the Block Range ridges. Few trees grow on the western stony plateaus.

Dense areas of woody shrubs extend across the sandplains. Mulga with ironwood (*Acacia excelsa*), white cypress pine, wilga (*Geijera parviflora*), gidgee (*Acacia cambagei*), brigalow (*Acacia harpophylla*), rosewood (*Heterodendrum oliefolium*), budda (*Eremphila mitchellii*), belah (*Casuarina cristata*) and sandhill wattle (*Acacia ligulata*) occupy sandplains, dunes and red soil rises. Poplar box lines depressions in red country and occurs on the grey soil floodplains in the east.

Black box (*Eucalyptus largiflorens*), coolabah (*Eucalyptus microtheca*), river cooba (*Acacia stenophylla*), yapunyah (*Eucalyptus ochrophloia*) and eurah (*Eremophila bignoniflora*), together with lignum (*Muehlenbeckia cunninghamii*), canegrass (*Eragrostis autralasica*), saltbush (*Atriplex* sp.) and copperburr (*Sclerolaena* sp.) are typical of the alluvial clays, with some gidgee, leopardwood and wilga on claypan margins. Sparse mulga can be found on lunettes.

7.2 Significant flora

Although there are no strictly endemic species in the Mulga Lands Bioregion, there are several significant flora species. These include spiny sedge (*Cyperus gymnocaulos*), bore-drain sedge (*C. laevigatus*, found only between Milparinka and Wanaaring), smooth heliotrope (*Heliotropium curassavicum*) and Ellangowan poison-bush (*Myoporum deserti*) towards the east of the bioregion (Cunningham *et al.* 1981, Morton *et al.* 1995).

The bioregion also supports a *Utricularia* species, most likely the golden bladderwort *Utricularia aurea*, which has one or two records from the Paroo River but is mostly found along the coastal fringe of eastern Australia (Cunningham *et al.* 1981, Morton *et al.* 1995). The salt pipewort *Eriocaulon carsonii*, listed as endangered in the TSC Act, has been identified as a relict species of the bioregion and is also found in SA and Qld (Briggs and Leigh 1995).

7.3 Significant fauna

A review of fauna information in 1997 showed that 256 bird, 56 mammal, 94 reptile and 23 amphibian species have been recorded for the bioregion (National Land and Water Resources website – www.nlwra.gov.au). The eucalypt woodlands associated with riparian areas show the highest species richness (Sattler and Williams 1999).

The western quoll (*Dasyurus geoffroii geoffroii*), once believed to have been present in the bioregion, is presumed to be extinct. The greater bilby (*Macrotis lagotis*), night parrot (*Pezoporus occidentalis*) and plains rat (*Pseudomys australis*) are all believed to be Mulga Lands species that are endangered (Sattler and Williams 1999).

The Mulga Lands support similar faunal assemblages to other semi-arid bioregions in NSW. The woodlands of the bioregion are particularly important for avifauna, including the limited range species, the Hall's babbler (*Pomatostomus halli*).

Photo: Murray Ellis

Numbers of freshwater birds increased in this bioregion due to an increase in rainfall from the first survey period (1977-1981) and the second survey period (1998-2001), as did ground nesters, some seed-eaters and insect-eaters as well as some woodland species. Grassland birds have not decreased significantly as is the trend in the majority of other bioregions (Australian Terrestrial Biodiversity Assessment 2002). Long-term trends indicate probable decline in bird species numbers as a result of ongoing land clearing in the bioregion.

Other significant fauna of the Mulga Lands is most often found in the wetlands of the bioregion, as detailed below.

7.4 Significant wetlands

There are six significant wetlands of the Paroo-Warrego area, which comprises the eastern half of the Mulga Lands Bioregion. All these wetlands are considered to be in good condition, providing habitat for large numbers of waterbirds.

Lower Bells Lake supports many waterbird populations, including the pink-eared duck (*Malacorhynchus membranaceus*) and grey teal (*Anas gracilis*), as well as providing nesting habitat for the black swan (*Cygnus atratus*).

The Cuttaburra Channels provide an important refuge for many waterbirds, sometimes to extreme numbers of up to 10,000 individuals. The floodplain has provided nesting habitat for the Pacific black duck (*Anas superciliosa*), Pacific heron (*Ardea pacifica*), black swan (*Cygnus atratus*), whiskered tern (*Sterna hybrida*), red-necked avocet (*Recurvirostris novaehollandia*) and straw-necked ibis (*Threskiornis aethiopica*).

The Kichimiloo Claypan area is also thought to provide habitat for up to 10,000 waterbirds.

The Kerribree Creek floodplain supports the annual grass channel millet (*Echinochloa inundata*), which is considered to be rare and was used as grain by local Aborigines prior to European settlement (Vickery 1975, cited in Cunningham *et al*. 1981). This wetland has also been described as providing habitat for up to 20,000 waterbirds.

Another significant wetland is the Warrego River floodplain, which could support up to 14,000 waterbirds. However, like many other wetlands in the area, feral animals, exotic weeds and changed hydrology are slowly degrading the current habitat values.

The Warrego/Darling River confluence provides a home for the vulnerable barking owl (*Ninox connivens*) and red-tailed black cockatoo (*Calyptorhynchus banksii*) (RAOU). The vulnerable Major Mitchells cockatoo (*Cacatua leadbeateri*) and brolga (*Grus rubicunda*), and the endangered Australian bustard (*Ardeotis australis)* have all been recorded in the vicinity of this wetland.

Threats to these wetlands are feral animals, exotic weeds, water extraction, sedimentation and grazing pressure.

Other significant wetlands include Peery Springs and Paroo Wetlands, which have been identified as refugia for biodiversity in the bioregion (Morton *et al*. 1995).

Peery Springs are a pair of mound springs at the edge of Peery Lake towards the centre of the NSW part of the Mulga Lands Bioregion. These springs have remained active in a part of the Great Artesian Basin where, of the 45 springs in NSW, most are no longer actively flowing (Morton *et al*. 1995). These springs are now protected in Peery National Park.

The Paroo Wetlands are an enormous wetlands complex which are located on pastoral leases in the bioregion as well as being partly reserved in Nocoleche

Nature Reserve which lies across this and the Darling Riverine Plains bioregions. The wetlands are formed in swamps and playa lakes that are filled about every five years, when floodwaters flow southwest from Qld along the Paroo and Warrego Rivers and Cuttaburra Creek (Morton *et al*. 1995). These wetlands are threatened by changes to hydrology resulting from agriculture and vegetation changes caused by overgrazing (Morton *et al*. 1995).

These wetlands also provide habitat for large populations of waterbirds, many of which, such as the freckled duck (*Stictonetta naevosa*), are significant to the bioregion (Morton *et al*. 1995).

8. Regional History

8.1 Aboriginal occupation

For information on the Aboriginal occupation of the Mulga Lands Bioregion, refer to Chapter 1 under the heading "Regional history".

8.2 European occupation

White Cliffs was the site of several pastoral stations in the 1880s. The discovery of the lucrative opal fields that it is most famous for was made quite by accident. Four kangaroo shooters hired to reduce kangaroo numbers on one of the stations found opals and sent them to Adelaide for valuation. The valuer, Tullie Cornthwaite Wollaston, was so impressed with the specimens that he became the main promoter of the town, selling the opals across the USA and Europe. A small settlement based on mining appeared in the area in the 1890s. The town was known as White Cliffs in reference to the white shale which harboured the opals. The first store and pub appeared in 1892 and by 1897, once word had got around of the potential of opals in the area, the town supported a population of about 1,000.

Due to the lack of adequate building materials and the unbearable heat in summer, miners began in 1894 to live in their used mine shafts that were cut into the solid sandstone. These underground dwellings were popular at White Cliffs as they provided a constant temperature throughout the year.

In 1902 the growth and economy of the town reached a peak as opals worth around £140,000 were discovered. This discovery attracted a large number of miners until World War I broke out in 1914 and the population of the town declined to its current status. The permanent population of White Cliffs stands at about 200, which rises in the winter months due to an influx of those seeking their fortune in gems. In 1987 the production of opals from the White Cliffs fields was estimated to be $150 million (Walkabout Australian Travel Guide website – http://www.walkabout.com.au/).

In contrast to White Cliffs, the town of Barringun on the Mitchell Highway at the Qld border has a population of four. Although this town once thrived, only a few abandoned buildings remain, but the pub is never deserted (Walkabout Australian Travel Guide website – www.walkabout.com.au).

9. Bioregional-scale conservation

The Mulga Lands Bioregion has, along with the majority of NSW bioregions, less than 20% of its area managed in conservation tenures. Together, they occupy about 157,428 ha or 2.40% of the bioregion.

Tenures provided for under the NPW Act 1974, and specifically national parks and nature reserves, are responsible for the majority of land included in conservation. The bioregion supports three reserves protected under the NPW Act 1974: Nocoleche Nature Reserve, Peery National Park and a small section of the Culgoa National Park, most of which is found in the adjacent Darling Riverine Plains Bioregion. Together these occupy an area of 114,170 ha or 1.74% of the bioregion. None of these reserves is also managed as wilderness under the Wilderness Act 1987. There are no Aboriginal areas, no historic sites, no state recreation areas and no regional parks in the bioregion. No voluntary conservation agreements have been entered into with landholders, but there are 8 wildlife refuges, which are held on properties occupying about 43,258 ha or 0.66% of the bioregion.

No property agreements (NVC Act 1997) have been entered into with landholders in the bioregion.

The bioregion has no land managed under the Forestry Act 1916.

Photo: Murray Ellis

10. Subregions of the Mulga Lands Bioregion

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Nebine Plains -	Cretaceous sandstones and claystones partly silicified. Quaternary aeolian sands and alluvial clays.	Low ridges partly overlain by dunes or sandplains. Channels and clay plains.	Red earths, brown loams on bedrock, red earths and red texture contrast soils on sandplains and cracking grey clays on fine alluvial sediment.	Mulga, western bloodwood, poplar box with mallee, white cypress pine, coolabah apple, silver-leaf ironbark and spinifex on ridges. Ironwood, mulga, white cypress pine, and wilga with gidgee and brigalow on sandplains. Black box, coolabah, and eurah with lignum and canegrass on clays.
Warrego River Plains	Quaternary alluvium and Aeolian sand.	Extensive alluvial plains with low sandy rises of the Warrego fan.	Red earths and red siliceous sands with widespread cracking grey and brown clays.	Coolabah, eurah, river cooba, lignum and canegrass on low areas. Black box fringing rises. Gidgee, brigalow ironwood, rosewood, wilga, white cypress pine, budda, poplar box, belah and dense shrubs on red soil rises.
Warrego Sands -	Quaternary aeolian and alluvial sediments with some groundwater influence.	Sandplains, channels, floodplains and minor basins on the lower Warrego fan.	Red earths, reddish texture contrast soils and grey clays.	Poplar box with belah, ironwood, gidgee, white cypress pine, beefwood, and red box. Mulga on stony areas. Dense woody shrubs. Coolabah, black box, river cooba with lignum, canegrass, saltbush and copperburr on clays, some gidgee, leopardwood and wilga on higher margins.
Ursino Sandplain -	Quaternary aeolian sands and alluvial sediments surrounding small areas of Cretaceous sandstone and Tertiary silcretes on tablelands.	Undulating sandplain with small areas of low, parallel dunes. Low tablelands and stony rises drained by local streams with small clay pans and depressions.	Loamy, calcareous red earths on sandplains, brown stony loams on tablelands and sandy red earths with minor grey clays on fine alluvial sediments.	Dense groves of mulga with ironwood, and some poplar box. Woody shrubs widespread. Canegrass and some black box on pans. Thinner mulga and western bloodwood on rises.
Paroo Sand Sheets -	Quaternary aeolian sands and alluvial sediments surrounding small areas of Tertiary silcretes stony plain.	Undulating stony plain and sandplain with low linear dunes. Channels, floodplains and clay pans of Cuttaburra Creek.	Stony red loams and earths on the rises. Sandy red earths and grey clays on sandplains and fine alluvial sediments.	Open mulga, leopardwood and shrubs on rises. Iron wood, mulga, white cypress pine, rosewood, poplar box, and belah with shrubs on sandplains. Ironwood, mulga, poplar box with gidgee, belah, yapunyah, coolabah and black box on alluvial sediments.
Paroo Overflow -	Quaternary alluvium and Aeolian sands on the lower alluvial fan of the Paroo River. Small areas of Palaeozoic bedrock.	Isolated rocky hills emerging from extensive source bordering dunefields. Clay plains and channels of the overflow system.	Pale red clayey sands, grey clays on fine alluvium.	Open mulga, rosewood and belah on hills and dunes. Canegrass, lignum, old man saltbush on clay pans with yapunyah and black box on margins.

10. Subregions of the Mulga Lands Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Paroo-Darling Sands -	Devonian quartz sandstone emergent hills surrounded by Quaternary Aeolian sands and alluvial clays of the lower Paroo.	Rounded ridges with rocky hillslopes, flanked by dunes and sandplain. Channels, floodplain and saline claypans with lunettes in the alluvial system.	Limited areas of stony loams on bedrock. Deep red earths and brown texture contrast soils on dunes and plains, grey and brown saline cracking clays on fine alluvium.	Mulga, belah, rosewood with sandhill wattle, beefwood, leopardwood and bluebush. Poplar box in depressions in red country. Canegrass, lignum and old man saltbush on clays with yapunyah and black box on channels and lake margins. Sparse mulga on lunettes.
Kerribree Basin	Quaternary alluvial and aeolian sands derived from Warrego overflow.	Low linear dunes, undulating plains with drainage sinks, and saline clay pans and swamps associated with channel systems.	Red siliceous sands, sandy red earths, brown loamy soils and grey and brown cracking clays.	Ironwood, belah and white cypress pone on dunes. Poplar box, mulga, belah gidgee and leopardwood on plains. Sparse coolabah, gidgee and black box with canegrass and some lignum on alluvial systems.
West Warrego	Cretaceous sandstones and claystones with Tertiary silcrete. Margins of Quaternary aeolian sands.	Low hills and dissected tablelands.	Shallow stony loams and sandy red earths.	Mulga and poplar box with occasional red box, western bloodwood, belah, rosewood, white cypress pine and ironwood.
White Cliffs Plateau	Cretaceous sandstones and claystones with marginal Quaternary colluvium and limited alluvium.	Stony plateau, dissected tablelands with escarpments and stony slopes. Contour banding evident on flatter slopes. Gravelly alluvial plains and floodouts of local creeks.	Red brown loams and clays, some texture contrast soils. Gravelly loams and limited brown clays in alluvium.	Mitchell grass on plateaus. Bladder saltbush and bluebush with small patches of belah and gidgee. Sparse mulga with saltbush and bluebush on stony plains and slopes. River redgum and yapunyah on larger creek lines. Mulga, poplar box on alluvial plains with coolabah, and river cooba on channels.

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http://www.walkabout.com.au/fairfax/locations/NSWWhiteCliffs.shtml

Mulga Lands Biogeographic Region (IBRA) - Location

Queensland

Tibooburra
Mount Sturt
Milparinka
Wanaaring
Yantabulla
Enngonia
Weilmoringle
Brewarrina
Bourke
Mount Oxley
Louth
Mount Gunderbooka
Byrock
White Cliffs
Fowlers Gap
Mootwingee
Wilcannia
Mount Grenfell
Mount Drysdale
Girilambone
Cobar
Hermidale
Nyngan
Emmdale
Nevertire
Nymagee
Tottenham
Broken Hill
Menindee
Ivanhoe
Trundle
Mossgiel
Manilla
Hillston
Booligal

0 25 50 75 Kilometres

PROJECTION : AMG z55

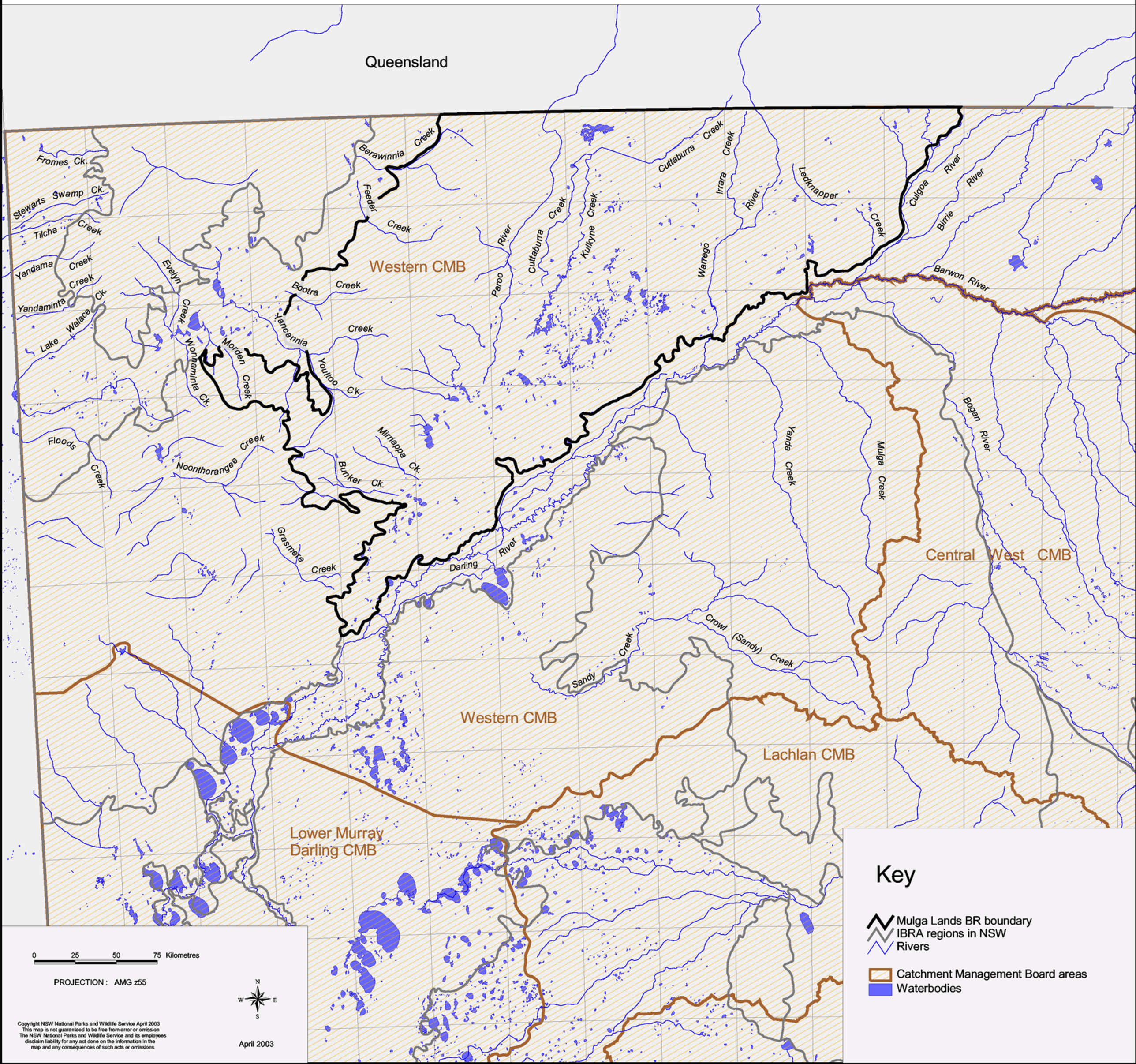
N W E S

April 2003

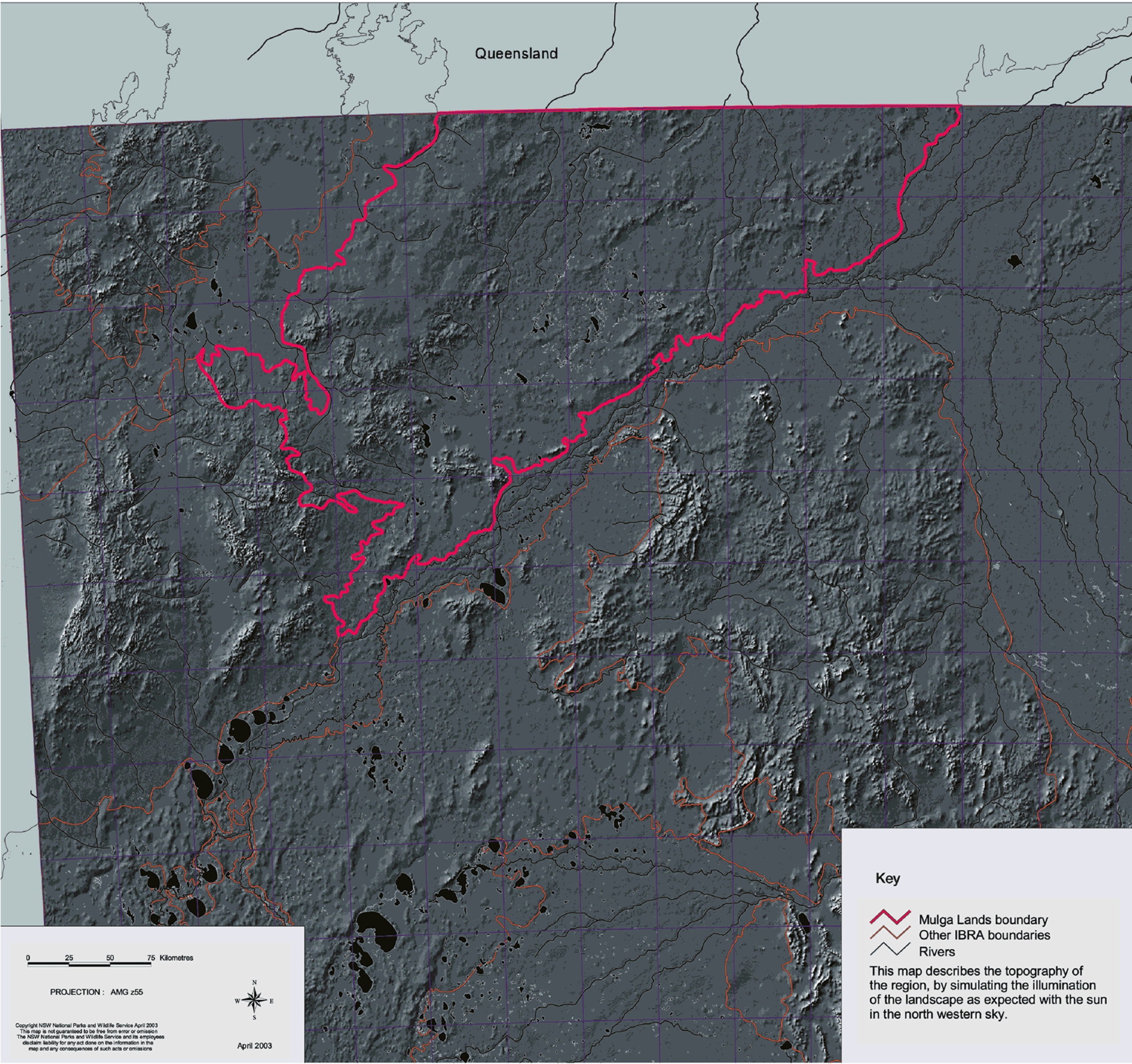
Key

- Towns
- Roads
- Rivers
- Waterbodies
- Mulga Lands
- IBRA regions in NSW
- IBRA regions interstate

Mulga Lands Biogeographic Region (IBRA) - Rivers



Mulga Lands Biogeographic Region (IBRA) - Topography



0 25 50 75 Kilometres

PROJECTION : AMG z55

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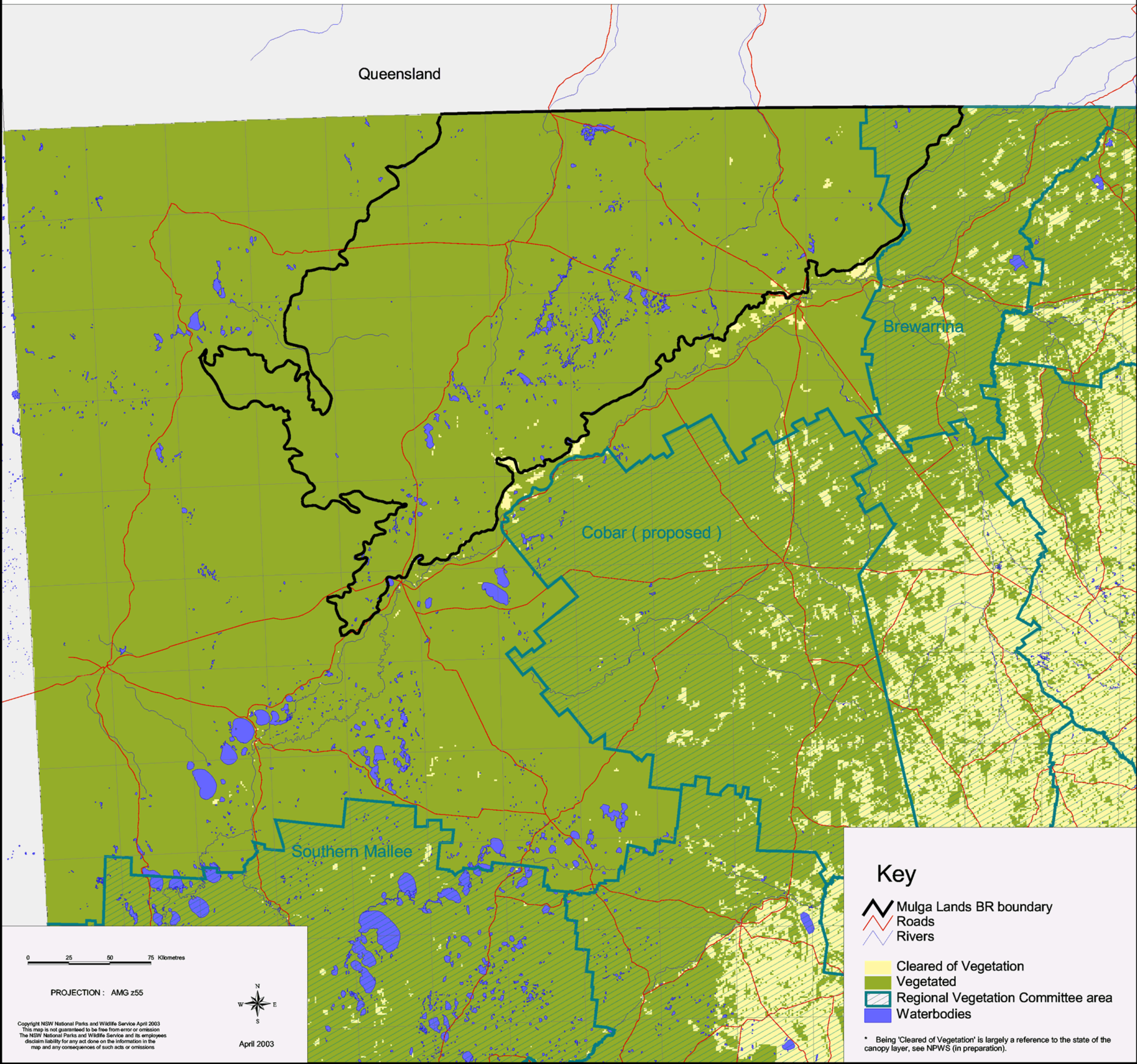
April 2003

Key

Mulga Lands boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

Mulga Lands Biogeographic Region (IBRA) - Vegetation



0 25 50 75 Kilometres

PROJECTION : AMG z55

N
W E
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April 2003

Key

- Mulga Lands BR boundary
- Roads
- Rivers

- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

Mulga Lands Biogeographic Region (IBRA) - Tenure/Reserves

Queensland

Key

- Mulga Lands BR boundary
- IBRA regions in NSW
- Roads
- Rivers
- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

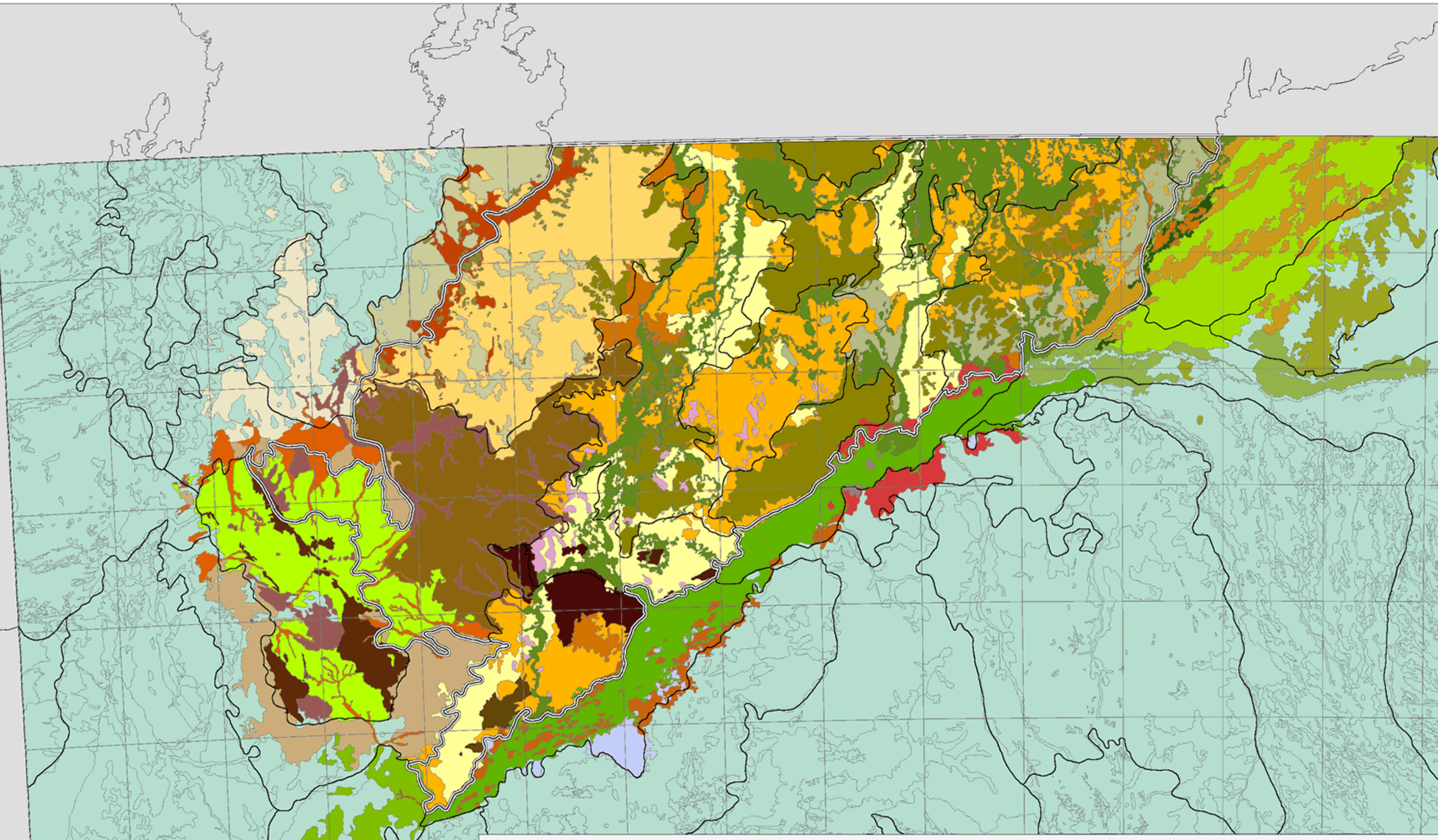
0 25 50 75 Kilometres

PROJECTION : AMG z54

N W E S

April 2003

Mulga Lands Biogeographic Region (IBRA) - Subregions and Landscapes (Mitchell, in preparation)



Key

Subregion boundaries (IBRA)

Mulga Lands (IBRA)

Landscapes of the Mulga Lands

- Barwon Channels and Floodplains
- Bulloo Linear Dunes
- Culgoa Channels and Floodouts
- Culgoa-Narran Alluvial Plains
- Culgoa-Narran Channels and Floodplains
- Mid Darling Alluvial Plains
- Mid Darling Channels and Floodplains
- Mid Darling Lakes and Swamps
- Mid Darling Plains
- Mid Darling Tablelands
- Mootwingee-Wonnaminta Alluvial Plains
- Mootwingee-Wonnaminta Downs
- Mootwingee-Wonnaminta Ranges
- Mootwingee-Wonnaminta Sandplains
- Mootwingee-Wonnaminta Tablelands
- Paroo-Warrego Alluvial Plains
- Paroo-Warrego Channels and Floodouts
- Paroo-Warrego Isolated Hills
- Paroo-Warrego Linear Dunes
- Paroo-Warrego Mt Murchison
- Paroo-Warrego Mt Pleasant
- Paroo-Warrego Plains
- Paroo-Warrego Salt Lakes
- Paroo-Warrego Sandplains
- Paroo-Warrego Tablelands and Downs
- Scopes Alluvial Plains
- Scopes Downs
- Upper Darling Tablelands and Downs
- Ursino Alluvial Plains
- Ursino Linear Dunes
- Ursino Sandplains
- Ursino Tablelands and Downs
- White Cliffs Alluvial Plains
- White Cliffs Sandplains
- White Cliffs Tablelands and Downs

Other Landscapes

IBRA regions interstate

0 25 50 75 Kilometres

PROJECTION : AMG z55

April 2003

CHAPTER 6

The Darling Riverine Plains Bioregion

1. Location

The Darling Riverine Plains Bioregion occupies a total area of 10,651,748 ha in northern NSW and Qld. The majority of the bioregion, 88.19% (9,394,263 ha), is in NSW and it occupies 11.74% of the state. The bioregion is surrounded by 6 others in both NSW and Qld, including the Brigalow Belt South Bioregion to the east, the Mulga Lands Bioregion to the northwest, and the NSW Southwestern Slopes, Cobar Peneplain, Murray Darling Depression and Broken Hill Complex bioregions in the south and southwest. The bioregion forms a bulky shape that extends into Qld, with a long, narrow riverine corridor that runs southwest along the Darling River. The main body of the bioregion extends from east of Bogabilla to Weilmoringle on the Qld border, south almost to Peak Hill and west to Nyngan and Bourke. The bioregion is traversed by the Western Division boundary.

In central north NSW, the Darling Riverine Plains Bioregion includes the lower reaches and alluvial fans of the Bogan, Macquarie, Castlereagh, Namoi, Barwon, Culgoa, Bokhara, Narran, Gwydir and Macintyre Rivers (Morgan and Terrey 1992). The Darling River corridor extends from Bourke almost to the southern edge of the Menindee Lakes, and south through the Murray Darling Depression Bioregion to the Victorian border where the Darling joins the Murray River.

The bioregion falls entirely in the Murray-Darling Basin and includes the Macintyre-Dumaresq, Culgoa, Narran, Warrego, Paroo, Moonie, Barwon, Gwydir, Namoi, Macquarie, Yanda, Castlereagh and Darling catchments.

2. Climate

The Darling Riverine Plains Bioregion lies in the semi-arid climatic zone which is hot and persistently dry (Stern *et al.* 2000). This semi-arid area occupies most of the western arm of the bioregion, accompanied by very small patches of both arid and warm semi-arid climate. The bioregion also contains minor patches of subtropical climate in the east with sub-humid areas in the southeast.

On average, the eastern portion of the bioregion receives higher and more reliable rainfall, with flooding occurring mainly in summer, while irregular cyclonic depressions can occur to the north of the bioregion (Morgan and Terrey 1992).

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
17 – 20°C	2.4 – 4.9°C	32.5 – 35.4°C	213 – 607mm	11 – 37mm	22 – 86mm

3. Topography

The Darling Riverine Plains Bioregion occupies most of the upper catchments of the Darling and Barwon Rivers in northern NSW and southern Qld and includes the channels and floodplains of the lower reaches of these catchments. The upper catchment landscape is a series of overlapping, low gradient alluvial fans. The lower tract of the river is a narrow floodplain confined between bedrock landscapes, or by extensive sandplains and dunefields. Discharge from past and present streams control patterns of sediment deposition, soils, landscapes and vegetation. Much of the geology and geomorphology of the region is similar to that of the Riverina Bioregion.

4. Geology and geomorphology

The main streams contributing water and sediment to the alluvial fans of the plains are the Bogan, Macquarie, Castlereagh, Namoi, Gwydir, Macintyre, Narran, Bokhara and Culgoa rivers. Sheets of alluvium up to 100m thick have been deposited on older sedimentary rocks and contain marine sediments of an inland sea of Cretaceous age. Almost all bedrock features have been buried in this sedimentary basin, with only a few high points of basement rocks such as Mt Foster rising above the plain, and more extensive areas of the Cretaceous sandstones forming low rises around Lightning Ridge and in the Collarenebri interfluve.

Tributary streams below Bourke are ephemeral and contribute little water or sediment to the main stream. Downstream of Wilcannia the Darling breaks into several channels (anabranches) that flow on roughly parallel courses for up to 200 km before joining the Murray.

The Darling River is subject to extreme flow variation. River discharge declines downstream as water is lost through seepage and evaporation. The upper margins of the plain, especially in sandy soils, are part of the recharge area of the Great Australian Basin. The river may have zero discharge for several consecutive months, alternating with regional floods that may last nearly 12 months.

Overall the landscape is flat with river channel and floodplain features dominant. Not all of the region has been effectively mapped but in those areas where detail is available, such as Nyngan-Walgett, the complexities of geomorphology and surface sediment distribution all reflect past climates and different river discharge regimes.

Each main stream carries different sediments depending on catchment geology and rainfall. The Bogan, for example, rarely flows strongly and only carries suspended clay past Nyngan. In contrast, the Castlereagh floods more often and carries a sand bed load because it drains extensive areas of Jurassic sandstones with higher rainfall. The Namoi deposits clays derived from volcanic rock so the floodplains below Narrabri are some of the most productive soils in the state.

The Macquarie is the largest tributary and has the most complex alluvial fan. This river drains a large area of the South Eastern Highlands Bioregion, and because its headwaters are in the high rainfall zones of the Great Dividing Range to the east it has a high discharge, is subject to large floods, and is sensitive to climate change. Any long-term change in average discharge causes the river to change form and shifts the location of sand or clay deposition on the alluvial fans.

Between Bourke and Wilcannia the confined Darling River channel has a simpler landscape of channel, floodplains, billabongs and slightly higher red soil terraces. Below Wilcannia the stream breaks into anabranches and is often attached to large circular or ovoid overflow lakes, which can be up to 15 km in diameter but are only a few metres deep.

Three types of wetland are found in the bioregion: delta-like swamplands, terminal drainage basins and lakes, and overflow lakes filled by floodwaters that drain back to the river as the flood recedes. The Macquarie Marshes are the most important and extensive example of a throughflow delta-like swamp in the bioregion. Narran Lakes are an example of terminal basins at the end of the Narran River, a distributary channel of the Balonne. The Menindee Lakes complex are the overflow lakes.

All lake beds consist of grey cracking clays and the eastern margins of most lakes have well-formed sandy beaches and crescent-shaped dunes or lunettes up to 25 m high which are composed of fine cemented quartz sand with some layers of pelleted clay.

5. Geodiversity

Important features of this bioregion include the following:

- the wetlands of this bioregion are the most important wetland habitats in the inland regions of the state;
- the Gwydir raft below Moree is a classic example of a giant debris dam that is now causing the main stream to change course across the Gwydir fan;
- Lightning Ridge, also within the bioregion, is the only commercial black opal field in the world;
- the entire bioregion is an important example of an inland drainage system where the streams flow into an arid region; the catchment has a long geological history and contains numerous sites that have the potential to yield information about past climates, past environments and human pre-history; only a few of these have been examined and they have become important heritage sites as a consequence; examples are Cuddies Springs and the lunette of Lake Tandou.

6. Soils

Soils and vegetation directly reflect past patterns of sedimentation and today's flooding regime, with some variation in plant species across the region relating to summer or winter rainfall dominance.

Sandy soils are found in linear belts along the older stream channels, sometimes with local source dunes on their border. Texture contrast soils, often badly eroded, are found marginal to channels of all ages, and most of the plains are dominated by deposits of heavy dark-coloured clays. Many clay areas have gilgai micro-relief patterns, most crack extensively, and others are more or less permanently wet in swamplands.

The sandy soils have low nutrient levels and drain rapidly. The clay soils vary more depending on source rocks in the catchment, but all have only a limited amount of free water available to plants. Most soils contain high levels of calcium carbonate and some are saline.

7. Biodiversity

7.1 Plant communities

Modern river channels in the bioregion support river red gum (*Eucalyptus camaldulensis*) and river cooba (*Acacia stenophylla*) communities, with some areas of river paperbark (*Melaleuca trichostachya*), especially along the tributaries of the Barwon. These species grow on the channel margin in the annual flood zone. Coolabah (*Eucalyptus microtheca*) can be found on the northern rivers.

Photo: G. Robinson

Trees on the more distant flood plains differ with locality. Yellow box (*Eucalyptus melliodora*) communities are found in the upper Macquarie, poplar box (*Eucalyptus populnea*) communities occur on the Bogan, coolabah communities are found on the Culgoa and most of the more northern streams support black box (*Eucalyptus largiflorens*) vegetation. Only the hardiest trees can survive the heavy clays of the backplains. These species include myall (*Acacia pendula*), poplar box and belah (*Casuarina cristata*) on the Bogan and Macquarie, and coolabah and black box on northern streams. Many plains are treeless, supporting only shrubs and grasses such as oldman saltbush (*Atriplex nummularia*), bladder saltbush (*Atriplex vesicaria*) and Mitchell grass (*Astrebla* sp.).

Landscapes closer to the hills support western plains woodlands, which consist of grey box (*Eucalyptus microcarpa*), Blakely's red gum (*Eucalyptus blakelyi*), silver-leaf ironbark (*Eucalyptus melanophloia*), poplar box, wilga (*Geijera parviflora*), rosewood (*Heterodendrum oleifolium*), belah, kurrajong (*Brachychiton populneum*), white cypress pine (*Callitris glaucophulla*), yarran (*Acacia homalophylla*), some brigalow (*Acacia harpophylla*) and several other species of *Acacia*.

Sandy soils on levees of old channels and dunes often have stands of white cypress pine. Lake beds may be bare or covered by clumped lignum (*Muehlenbeckia cunninghamii*) with a fringe of black box. Lunettes support stands of belah, some mallee, white pine, prickly wattle (*Acacia victoriae*), black bluebush (*Maireana pyramidata*), and sandhill canegrass (*Zygochloa paradoxa*).

On the lower reaches of the Darling through the anabranch, river red gums line the banks with old man saltbush and lignum. Billabongs and floodplains are characterised by black box, canegrass (*Eragrostis australasica*) and lignum, and adjacent dunes support prickly wattle, belah, narrow-leaf hopbush (*Dodonea attenuata*) and various bluebush species.

Swamp vegetation varies with duration and depth of flooding. Marshes supplied with more permanent water support associations of common reed (*Phragmites australis*), cumbungi (*Typha* sp.), water couch (*Pseudoraphis spinescens*) and aquatic species such as water milfoil (*Myriophyllum propinquum*) and duckweed (*Lemna minor*). Less frequently flooded swamps support lignum and grasslands, especially water couch, and nardoo (*Marsilea hirsuta*) is also common.

7.2 Significant flora

Nineteen species listed in the TSC Act 1995 are known to occur within the Darling Riverine Plains Bioregion. Nine of these species are endangered and 10 are considered vulnerable (NSW NPWS 2001).

The Culgoa River floodplain supports a number of endangered species including the narrow-leaf bumble (*Capparis loranthifolia* var. *loranthifolia*) and climbing caustic (*Euphorbia sarcostemmoides*) (Kearle *et al*. 2002). Regionally rare species occurring on the floodplain include bull wiregrass (*Aristida longicollis*), wirewood (*Acacia coriacea*), bowl daisy (*Pluchea dentex*), hairy spurge (*Phyllanthus carpentarie*) and sandplain riceflower (*Pimelea penicillaris*) (Environment Australia 2001).

Four species known to occur within the Darling Riverine Plains Bioregion are now listed in the TSC Act as extinct in NSW. All of these are known from only one or two records and all are recorded in the Atlas of NSW Wildlife (NSW NPWS 2001).

Other species of conservation significance that have been recorded in the bioregion include the rare plants *Echinochloa lacunaria, Leptorhyncos waitzia, Ipomoea diamantinensis, Ptychosperma anomalum, Swainsona adenophylla, S. laxa,* and *Solanum karsensis* (Bowen and Pressey 1993, cited in Morton *et al*. 1995).

The Darling Riverine Plains Bioregion includes the following endangered ecological communities listed in the TSC Act:

- *Acacia loderi* shrublands;
- artesian Springs ecological community;
- Carbeen (*Corymbia tessellaris*) open forest community in the Darling Riverine Plains and Brigalow Belt South bioregions; and
- native vegetation on the cracking clay soils of the Liverpool Plains.

Two endangered ecological communities in the Darling Riverine Plains Bioregion are listed under the Commonwealth EPBC Act 1999. These are:

- Brigalow (*Acacia harpophylla* dominant or co-dominant); and
- the community of native species dependent on the natural discharge of groundwater from the Great Artesian Basin (Kearle *et al*. 2002).

7.3 Significant fauna

The bioregion is home to 25 amphibian species, 104 reptile species, 319 bird species and 58 mammal species. Of these, 63 species are listed in the TSC Act: 9 as extinct, 12 as endangered and 47 as vulnerable.

Records of amphibians in the Darling Riverine Plains include 7 species that are either endemic or largely restricted to the bioregion (Kearle *et al*. 2002). These are *Crinia parinsignifera, C. sloanei, Limnodynastes fletcheri* (long-thumbed frog), *Limnodynastes interioris* (giant banjo frog), *Neobatrachus sudelli, Notaden bennettii* (crucifix toad) and *Cyclorana verrucosa*.

No frog species known or predicted to occur in the Darling Riverine Plains Bioregion is listed as threatened in NSW. Although there are also no threatened populations of amphibians in the bioregion listed under the TSC Act, there have been no detailed studies of their status in the bioregion and areas such as the Gingham wetlands are considered to be worthy of such assessment (Kearle *et al*. 2002).

Six reptile species within the bioregion are listed in the schedules of the TSC Act, 1995. The fierce snake is listed as extinct in NSW, while 4 species are listed as vulnerable and one species, *Anomalopus mackayi*, is listed as endangered.

A number of reptile species recorded in the bioregion are either endemic or largely restricted to the bioregion (Kearle *et al*. 2002). These include *Emydura macquarii, Delma plebia* (leaden delma), *Ctenotus allotropis, Ctenotus brachyonyx, Egernia modesta, Hemiaspis damelii* (grey snake), *Pseudechis guttatus, Simoselaps australis* (coral snake), *Anomalopus leuckartii* (two-clawed worm-skink) and *Anomalopus mackayi* (listed under the TSC Act as endangered). The range of the worm-skink *Anomalopus mackayi* is largely restricted to the Darling Riverine Plains (Cogger 1992). Its range has decreased because suitable habitat has been cleared for cropping or degraded by grazing (Cogger *et al*. 1993; Sadlier and Pressey 1994, cited in Morton *et al*. 1995).

Several species of snake are also affected by clearing of habitat (Morton *et al*. 1995). These include elapid snakes (*Echiopsis curta*), which are confined to mallee areas of the bioregion, the *Notechis scutatus* and the python *Morelia spilota variegata*, both of which are found in the riverine environs along the Murray-Darling system.

Waterbirds are a significant component of the bird fauna of the Darling Riverine Plains and have been more extensively studied than other bird species (Kearle *et al*. 2002). Thirty-five bird species in the bioregion have been listed in the TSC Act, 8 as endangered and 27 as vulnerable (NSW NPWS 2001). Subtropical woodlands which occur in parts of the Darling Riverine Plains (as well as in portions of the Brigalow Belt South, Nandewar and New England Tableland bioregions) are recognised as key habitat areas for the conservation of threatened or near-threatened bird species (Garnett and Crowley 2000, cited in Kearle *et al*. 2002). Many waterbirds are known to breed in the bioregion, including the freckled duck (*Stictonetta naevosa*) (Blakers *et al*. 1984, cited in Morton *et al*. 1995).

A large proportion of the distribution of several bird species falls in the Darling Riverine Plains Bioregion. Such species include the spotted bowerbird (*Chlamydera maculata*), striped honeyeater (*Plectorhyncha lanceolata*) and plum-headed finch (*Neochemia modesta*) (Kearle *et al*. 2002). In NSW, the red-tailed black cockatoo (*Calyptorhyncus banksii graptogyne*) occurs largely in association with *Eucalyptus camaldulensis* woodland, where it uses large hollows for nesting (Smith *et al*. 1994, cited in Kearle *et al*. 2002). Most NSW records of red-tailed black cockatoos are from this bioregion, generally in the vicinity of the Barwon-Darling River (Kearle *et al*. 2002).

Twenty-two threatened mammal species described for the bioregion are listed in the TSC Act. Ten species, including the numbat (*Myrmecobius fasciatus*), bilby (*Macrotis lagotis*) and burrowing bettong (*Bettongia lesueur*), are listed as extinct in NSW. Nine species are listed as vulnerable and 3 species, the kultarr (*Antechinomys laniger*), southern hairy-nosed wombat (*Lasiorhinus latifrons*), which was recently rediscovered in this and the Murray Darling Depression Bioregion, (Ayers *et al*. 1996) and the silky mouse (*Pseudomys apodemoides*), are listed as endangered. (All three have TS profiles and the silky mouse is known from only one record.)

Populations of swamp wallaby (*Wallabia bicolor*), common brushtail possum (*Trichosurus vulpecula*), koala (*Phascolarctus cinereus*) and glider (*Petaurus spp.*), have been recorded in several surveys in the bioregion and are considered to be regionally significant (Smith *et al*. 1998, cited in Kearle *et al*. 2002), although they are not listed under the TSC Act. Populations of the greater long-eared bat (*Nyctophilus timoriensis*) and the yellow-bellied sheathtail bat (*Saccolaimus flaviventris*) are considered to be sparse and at risk because their tree-roosting behaviour leaves them exposed to loss of habitat and predation by cats (Dickman *et al*. 1993, cited in Morton *et al*. 1995).

The two-spined blackfish (*Gadopsis bispinosus*), Murray jollytail (*Galaxias rostrattus*), Australian rainbowfish (*Melanotaenia fluviatilis*), Macquarie perch (*Macquaria australasica*), Murray cod (*Maccullochella peeli*) and silver perch (*Bidyanus bidyanus*) are endemic to the Murray-Darling system (Lloyd *et al*. 1991, cited in Morton *et al*. 1995).

A number of feral, introduced mammals have been recorded in the bioregion, including foxes, cats and pigs.

The bioregion supports river red gum (*Eucalyptus camaldulensis*) corridors along the Darling River and nearby floodplains, which are important for the diversity of birds in the bioregion, including many species that are more common to the wetter bioregions in the south or east. Species such as the vulnerable superb parrot (*Polytelis swainsonii*) use these river red gum habitats or nearby woodlands, while the adjacent reedy swamps are home to the vulnerable Australasian bittern (*Botaurus poiciloptilus*). The pied currawong (*Strepera graculina*), little raven (*Corvus mellori*) and Torresian crow (*Corvus orru*) have increased in number in the bioregion, as have numbers of freshwater, woodland and forest species and some ground-feeding granivores. Species are likely to be lost unless efforts are made to protect, enhance and link forest fragments. Hollows within riparian forests in the bioregion must also be retained.

The distribution of the smooth knob-tailed gecko (*Nephrurus levis*) reaches its far eastern limit in the Broken Hill Complex Bioregion (Cogger 1992).

7.4 Significant wetlands

There are several bioregionally significant wetlands in the bioregion. The Namoi River Floodplain provides important habitat for the endangered bush stone curlew (*Burhinus grallarius*), even though its condition has been described as poor and still declining. Several vulnerable species, such as the koala (*Phascolarctos cinereus*), painted honeyeater (*Grantiella picta*) and brolga (*Grus rubicundus*) have been sighted on the floodplain.

Nettlegoe Lake occurs mainly in the Darling Riverine Plains Bioregion, with a small part extending into the Murray Darling Depression. It is described as being in fair condition. In 1993, Kingsford *et al*. (1997) recorded more than 10,000 waterbirds here including grey teal (*Anas gracilis*), pink-eared duck (*Malacorhynchus membranaceus*) and Eurasian coot (*Fulica atra*). The vulnerable freckled duck (*Stictonetta naevosa*) was recorded on the lake in 1983, 1990, 1993 and 1999.

Poopelloe Lake is another significant wetland within the bioregion, although it has been described as degraded and its condition is declining. Kingsford *et al*. (1997) used modelling to predict that the lake could support 20,000 waterbirds. The vulnerable Major Mitchell's cockatoo (*Cacatua leadbeateri*) has been recorded at the lake. Modelling has also been used for Wongalara Lake, also significant in the bioregion, to predict that it could provide habitat for 12,000 waterbirds.

The Darling River floodplain is another significant wetland, which supported almost 139,000 waterbirds in 1984. The species with the highest abundance were grey teal (*Anas gracilis*), hardhead (*Aythya australis*), black-tailed native hen (*Gallinula ventralis*) and Australian pelican (*Pelecanus conspicillatus*). In the same year the floodplain provided nesting habitat for almost 200 yellow-billed spoonbill (*Platalea flavipes*). In 1998, Pacific black duck (*Anas superciliosa*) also used the area for nesting.

This section of the Darling River is important for many threatened species. The vulnerable Major Mitchell's cockatoo, red-tailed black cockatoo (*Calyptorhynchus banksii*) and Australasian bittern (*Botaurus poiciloptilus*) have all been recorded here (NSW NPWS 2001).

Wetlands in the Darling Riverine Plains Bioregion are affected by changed hydrology, often where water regulation and abstraction results in increased flows for the lakes and decreased flows for the floodplains. Construction of levee banks, lakebed cropping and weir construction upstream is also a problem for some of the wetlands. Other impacts include feral animals, exotic weeds, salinity and grazing pressure. Despite these impacts, the wetlands still provide important habitat for waterbirds in the bioregion, and indeed across the state.

8. Regional History

8.1 Aboriginal occupation

For information on the Aboriginal occupation of the Darling Riverine plains, refer to Chapter 1 under the heading "Regional history"

8.2 European occupation

Pastoralists reached Menindee by 1850 and, like other towns such as Wilcannia, the town was developed as a Darling River port (NSW NPWS 1991).

A drover who camped where the town now stands during a spectacular storm gave the name to Lightning Ridge (NSW NPWS 1991). In 1902 the children of a boundary rider discovered some colourful stones which were later identified as opals. Within a year, the mining town of Lightning Ridge emerged and for some time was bathed in riches. The town was surrounded by several huge sheep stations whose owners employed opal miners with casual positions in fencing, timber cutting, carting wool and labouring their properties (NSW NPWS 1991).

Sheep grazing, cotton growing and tourism are the primary forms of land use in the bioregion (Morton *et al.* 1995).

Morton *et al.* (1995) identified the following management problems with the Darling Riverine Plains bioregion:

- land degradation through over-grazing;
- declining water quality in the rivers of the bioregion, mainly as a result of removal of water for irrigation and from increased salinity caused chiefly by irrigation runoff;
- clearing for agriculture in marginal lands; and
- control of vertebrate pests.

9. Bioregional-scale conservation

The Darling Riverine Plains Bioregion has a low conservation status in terms of overall area managed for conservation, which is 325,113.32 ha or 3.47% of the bioregion.

Lands managed under the provisions of the NPW Act contribute the most to land managed for conservation. However, lands currently managed as wildlife refuges contribute the most in terms of area. Culgoa and Kinchega National Parks (NPW Act 1974) lie within the bioregion, crossing bioregional boundaries into the Mulga Lands and Broken Hill Complex bioregions respectively. These, together with 7 nature reserves, 6 of which, including the Macquarie Marshes and Narran Lake Nature Reserves, lie wholly in the bioregion, occupy 87,410.26 ha or 0.94% of the bioregion. None of these reserves is also managed as wilderness under the Wilderness Act 1987.

Photo: G. Croft

None of the provisions of the NPW Act 1974 has been used to conserve land as historic sites, Aboriginal areas, state recreation areas or regional parks in the bioregion. However there is one voluntary conservation agreement occupying 18.98 ha (0.0002%) of the Darling Riverine Plains Bioregion, and 38 wildlife refuges which occupy 210,648.69 ha or 2.24% of the bioregion. Four property agreements (under the provisions of the NVC Act 1997) occupy about 421 ha or 0.0045% of the bioregion.

Land managed under the provisions of the Forestry Act 1916 includes 22 State forests (19 of which are wholly within the bioregion) which occupy 14,825 ha or 0.16% of the bioregion and one flora reserve (14.62 ha or 0.0002%), also wholly within the bioregion.

No data are currently available on conservation zones within State forests.

10. Subregions of the Darling Riverine Plains Bioregion

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Bogan-Macquarie -	Bogan and Macquarie River alluvial fans of Quaternary age. Western margin is bedrock of the Cobar bioregion. Alluvial sediments from mixed Palaeozoic bedrock bury basement rock to 100m. Underlying sediments of Cretaceous and Jurassic age form part of the Great Artesian Basin.	Channels, floodplains, and through flow swamps of past and present river systems.	Grey and brown clays on the plains and depressions with texture contrast soils on the low rises of former levees and channels.	River red gum and river cooba on the channels. White cypress pine and poplar box on coarser levees. Black box, belah, myall and lignum on floodplains. Complex patterns of common reed, cumbungi, and water couch depending on water levels in marshes. Poplar box woodland with wilga, budda, white pine, grey box, yellow box and Blakely's red gum on red soils on fan margins.
Castlereagh-Barwon -	Extensive plains on overlapping low angle alluvial fans of several rivers. Sediment derived from Jurassic sandstones on the Castlereagh fan and from basalts on the Namoi fan. Same structure as Bogan-Macquarie.	Channels, floodplains, crevasse splays, levees, source bordering dunes and through flow swamps of past and present river systems.	Grey and brown clays on the plains and depressions. Brown loamy sands, pale yellow or red sands, and texture contrast soils on the low rises of former levees and channels.	River red gum on larger streams. Coolabah with occasional myall, river cooba, whitewood belah and clumps of river paperbark. Mitchell grass with few trees on clay plains. Poplar box with wilga, whitewood, belah, white cypress pine, silver-leaf ironbark and occasional brigalow on higher red soils.
Culgoa-Bokhara	Clay plains of the alluvial fans of the Culgoa and Bokhara Rivers. All fine sediments of Quaternary age.	Channels, floodplains, and swamps of past and present river systems.	Grey clays on almost all landscapes.	Coolabah, river cooba and lignum along channels with some river red gum. Widespread Mitchell grass on the clay plains with some saltbush, patches of gidgee, wilga, leopard wood and poplar box.
Warrambool-Moonie	Alluvial fan and plains constructed by high level overflows from the Balonne River. Fine sediments of Quaternary age.	Channels, floodplains, and swamps of past and present river systems. These channels are usually dry but can be filled by high level flows in the Moonie and Balonne Rivers.	Grey clays on almost all landscapes.	Coolabah, river cooba, eurah and lignum along channels with some river red gum. Coolabah woodland with poplar box, belah, budda, wilga and myall on the plains. Limited white cypress pine on rare sandy soils.
Narran-Lightning Ridge	Cretaceous sandstones and claystones on the ridges. Terminal lake basins. Extensive floodplains of grey clay and limited sands of Quaternary age.	Low ridges on the sandstones, relief to 20m. Channels, floodplains, lakes and lunettes swamps of past and present river systems. These channels carry level flows in the Balonne and Maranoa Rivers.	Stony red earths on the ridges. Grey clays over most of the plains with sandy soils and some texture contrast soils on levees, low sand dunes and lunettes.	Silver leaf ironbark, white cypress pine, western bloodwood and mulga on the ridges. Poplar box on lower slopes with loamy soil. Coolabah, river red gum on channels and lake margins. Lignum in swamps and open water in Narran lakes.

10. Subregions of the Darling Riverine Plains Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Collarenebri interfluve - One land system only	Cretaceous sandstones and claystone that are a small part of the Surat Sandstones subregion in Queensland.	Low rounded hills, relief to 10m, local dendritic drainage patterns.	Stony red earths often with a gravel pavement. Soils become deeper down slope and accumulate calcium carbonate in drainage lines.	Bimble box, wilga, white cypress pine, budda, warrior bush, ironwood, and belah with mixed grasses underneath.
Louth plains -	Alluvial plains of the mid-Darling valley, confined between the Cobar peneplain and Mulga lands bioregions. Shallow Quaternary alluvial sediments over bedrock.	Channel and floodplain features. Anabranch streams rare, occasional small dunes.	Grey clays from channels to backplains with limited areas of higher red soils and patchy sands probably representing alluvial terraces.	Coolabah, river red gum, river cooba and some black box along the channels. Canegrass and lignum in depressions, with saltbush, bluebush and grasses on backplains. Poplar box, rosewood and some black box on red soils and valley margins.
Wilcannia Plains -	Alluvial plains of the mid-Darling valley, confined between the Cobar peneplain and Mulga lands bioregions. Shallow Quaternary alluvial sediments over bedrock.	Channel and floodplain features. Anabranch streams present feeding valley margin lakes. Limited areas of dunes and sandplains.	Grey clays from channels to backplains and on lake beds. Red soils and patchy sands probably representing alluvial terraces.	Coolabah, river red gum, river cooba and black box along the channels. Canegrass and lignum in depressions, with saltbush, bluebush and grasses on backplains. Poplar box, belah, rosewood, black bluebush and black box on red soils and valley margins.
Menindee -	Quaternary alluvial complex of river and lake sediments with associated aeolian landforms.	Channel and floodplain features, well developed anabranch streams and overflow lakes with lunettes and extensive sandplains and low dunes.	Grey clay and white sand in channels, lake beds and beaches. Brown clays on swamps, merging to red sands and some texture contrast soils on sandplains. Lunettes of white or pale yellow sand alternating with layers of pale brown pelleted clay.	River red gum, river cooba and black box along the channels and lake margins. Canegrass and lignum in swamps and depressions. Saltbush, bluebush, turpentine, prickly wattle, and grasses with belah, and rosewood, on red soils. Bluebush and sandhill canegrass on lunettes.
Great Darling Anabranch	Quaternary alluvial complex of river and lake sediments with associated aeolian landforms.	Channel and floodplain features of the Great Darling Anabranch with overflow lakes, lunettes and extensive sandplains and low dunes. This system carries high level Darling River flows.	Grey clay in channels, floodplains and lake beds. Limited areas of red sands and texture contrast soils. Lunettes of white or pale yellow sand alternating with layers of pale brown pelleted clay.	River red gum on channels, black box and river cooba widespread on floodplains. Lignum and black box on lake margins. Belah, white cypress pine, prickly wattle and bluebush on lunettes.
Pooncarie-Darling	As for the Great Darling Anabranch.	This system carries low level Darling River flows.	As for the Great Darling Anabranch.	As for the Great Darling Anabranch.

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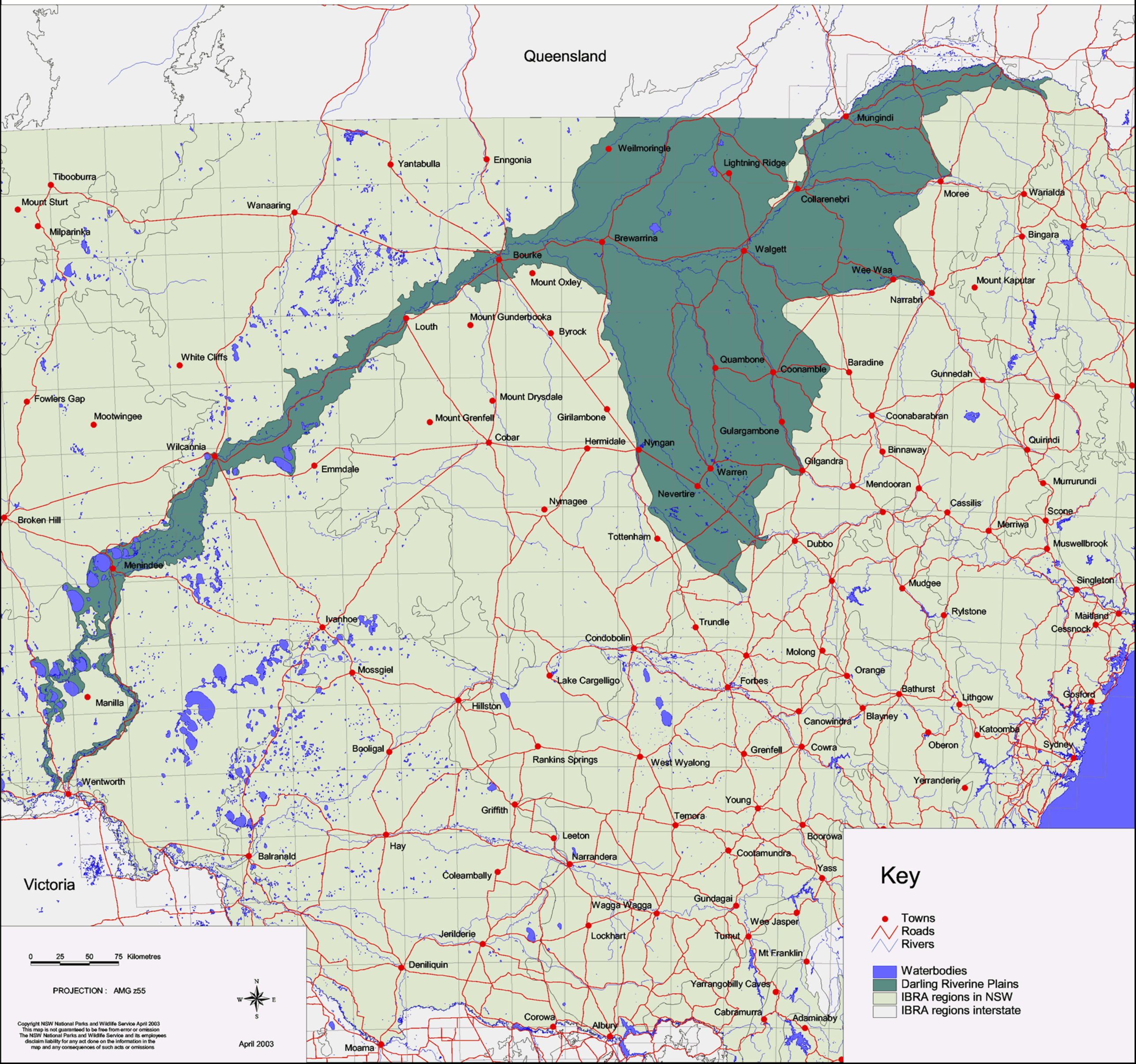
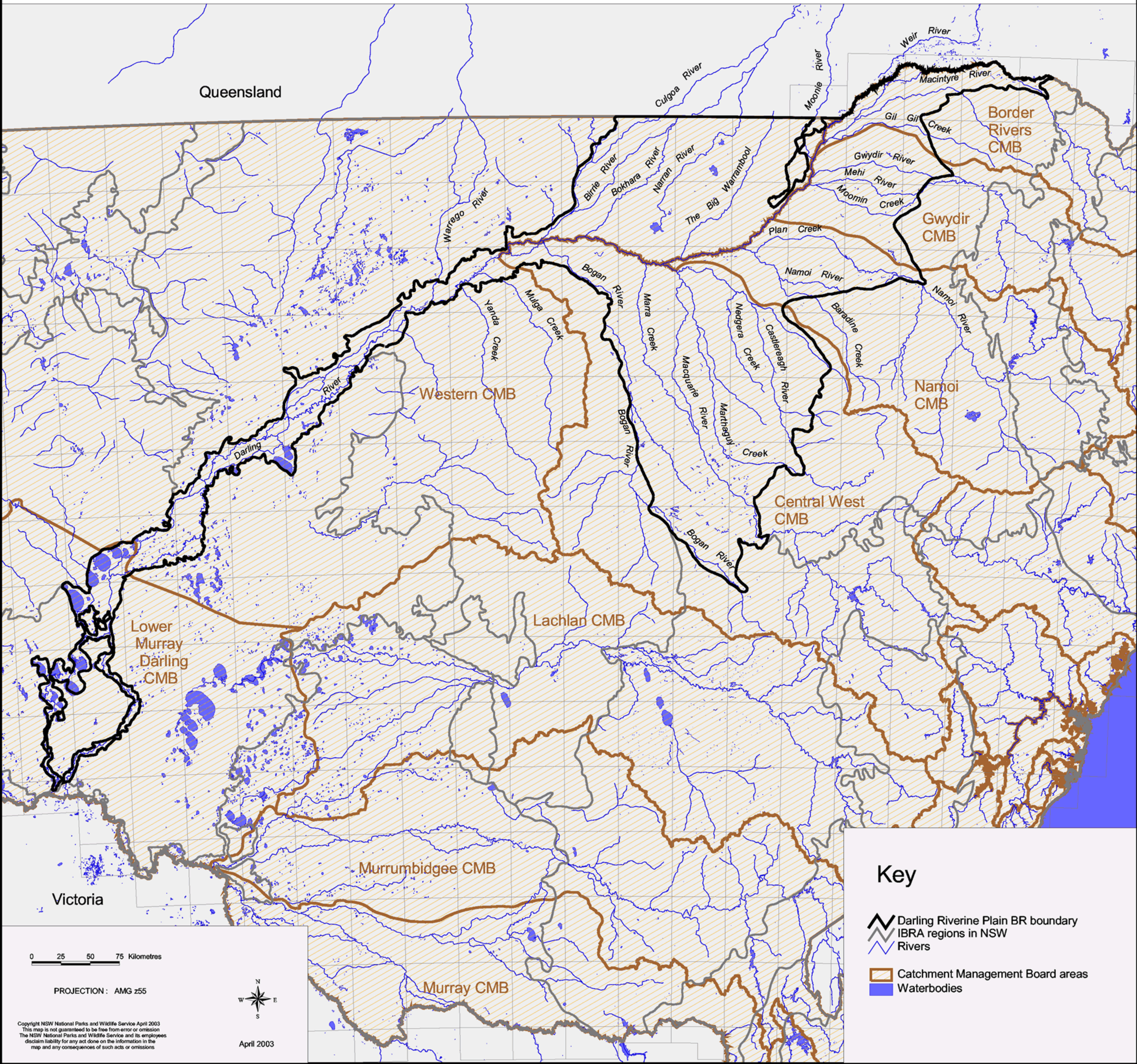
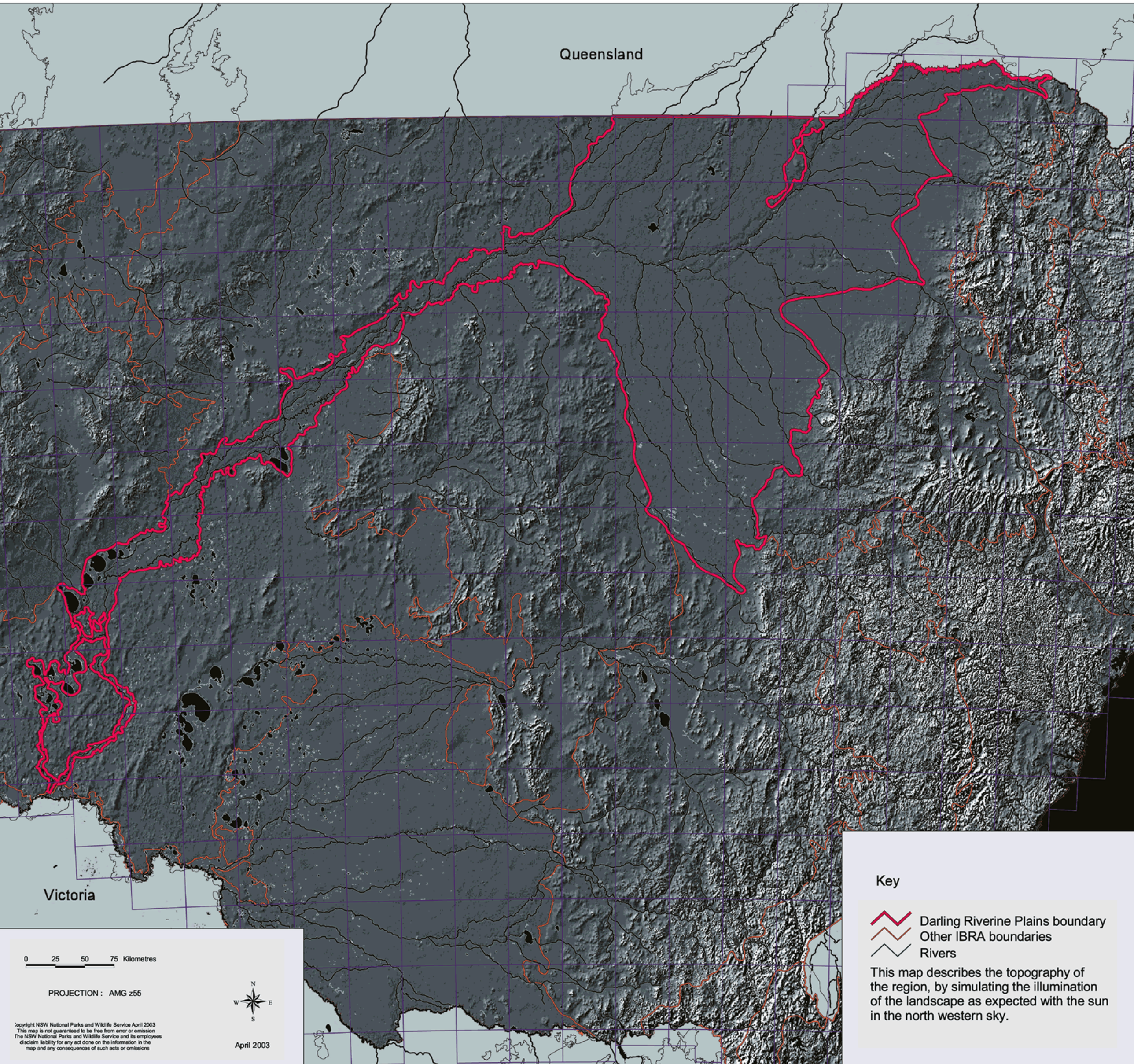
Darling Riverine Plain Biogeographic Region (IBRA) - Location



Darling Riverine Plain Biogeographic Region (IBRA) - Rivers



Darling Riverine Plain Biogeographic Region (IBRA) - Topography



0 25 50 75 Kilometres

PROJECTION : AMG z55

N
W E
S

April 2003

Key

Darling Riverine Plains boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

Darling Riverine Plain Biogeographic Region (IBRA) - Vegetation

Queensland

Brewarrina

Walgett

Moree

Inverell-
Yallaroi

North
Western
Slopes

Northern
Slopes
& Plains

Lower Macquarie -
Castlereagh

Cobar (proposed)

Bogan/
Nth Lachlan

Hunter Valley

Mid - Lachlan

Southern Mallee

Western Riverina

Riverina
Highlands

Victoria

0 25 50 75 Kilometres

PROJECTION : AMG z55

N
W E
S

April 2003

Key

- Darling Riverine Plain BR boundary
- Roads
- Rivers

- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

Darling Riverine Plain Biogeographic Region (IBRA) - Tenure/Reserves

Queensland

Victoria

0 25 50 75 Kilometres

PROJECTION : AMG z55

N
W E
S

April 2003

Key

- Darling Riverine Plain BR boundary
- IBRA regions in NSW
- Roads
- Rivers

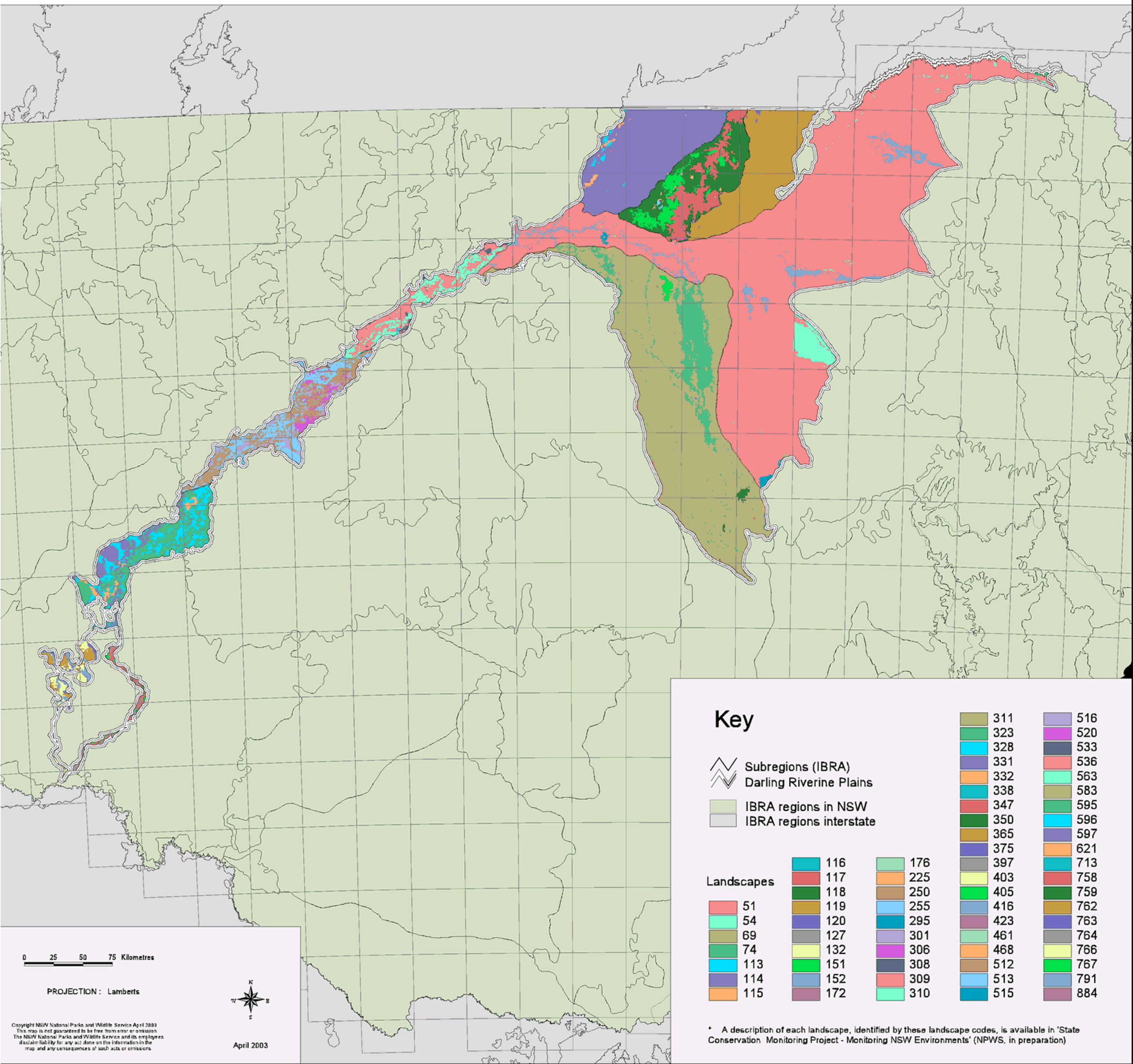
- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

Darling Riverine Plains Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)



* A description of each landscape, identified by these landscape codes, is available in 'State Conservation Monitoring Project - Monitoring NSW Environments' (NPWS, in preparation)

CHAPTER 7

The Murray Darling Depression Bioregion

1. Location

The Murray Darling Depression Bioregion lies in the southwest corner of NSW and extends into Vic and SA. The total area of the bioregion is 19,717,651 ha with 40.71% (8,026,167 ha) of this area in NSW and covering 10.03% of the state.

The NSW portion of the bioregion is bounded in the north by the Broken Hill Complex Bioregion, with the Cobar Peneplain to the northeast and the Riverina Bioregion to the east. The Murray Darling Depression Bioregion also borders the Darling Riverine Plains to the northwest and contains outlying remnants of the Darling River and tributaries as they meet the Murray River at the Victorian border.

The bioregion lies entirely in the Western Division of NSW and contains few town centres, with Ivanhoe, just near the tip of the Riverina Bioregion, being the major settlement aside from Manilla, Emmdale and other pastoral stations in the bioregion.

The bioregion includes the Murray, Murrumbidgee, Lachlan, Darling, Barwon, Yanda River and Peacock Creek catchments.

2. Climate

The Murray Darling Depression Bioregion is dominated by a hot semi-arid climate in the northern section of the bioregion including the northeastern arms, and a warm semi-arid climate in the southern half of the bioregion and eastern outliers. Small patches in the west of the bioregion fall in the NSW arid zone (Stern *et al.* 2000).

3. Topography

The Murray Darling Depression Bioregion lies in the Murray Basin on Tertiary and Quaternary sediments deposited from a shallow sea, lakes and rivers. The bioregion extends into Vic and SA. The landscape is characterised by dunefields, sandplains and undulating plains of brown calcareous soils. There is very little structured drainage but numerous lakes, swamps and depressions are present, some of which are driven by saline groundwater.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
16 – 19°C	2.9 – 4.9°C	32.4 – 35°C	210 – 408mm	12 – 29mm	22 – 40mm

4. Geology and geomorphology

The Murray Basin is a shallow crustal depression filled with marine and terrestrial sediments to a maximum depth of 600m over the last 50-60 million years. Shallow seas have moved back and forth across the plains several times, leaving traces of parallel beach ridges and limestone sediments under the dunefields. At one stage the coast reached as far inland as Balranald.

Sandy surface sediments have been extensively reworked into dunes and sandplains that have blown onto the Cobar Peneplain. Some dunes have consistent east-west linear patterns, others are parabolic, suggesting differences in vegetation cover, sand supply or age. The Darling River and streams in the Riverina have cut through the sands and constructed numerous overflow lakes such as the Sayers Lake system and the abandoned Pleistocene channels and basins of the Willandra Lakes complex. Saline groundwaters have formed salt basins in many places where the sandplain or dune topography intersects the water table. All lakes and swamps have well-formed lunettes on their eastern margins that record evidence of climate change and human occupation. A few bedrock ridges rise above the sandplains as isolated ranges.

5. Geodiversity

The Murray Darling Depression Bioregion has many important wetlands. Other significant geodiversity features include:

- flooding frequency varies and water quality and lake or swamp environments are very diverse;
- abandoned systems, such as the Willandra Lakes, preserve evidence of past climates and environments along with abundant archaeology; there are many equivalent lunette sites that have not yet been examined;
- heavy sand mineral resources and large deposits of gypsum are known but not exploited.

6. Soils

Soils and vegetation differ according to the landform. On the dunefields red, brown and yellow calcareous sands occur with more clayey materials in the swales. On sandplains the soil tends to be heavier with brown gradational or texture contrast profiles, and mallee is found only on sandy rises.

Lakes and depressions all have clay floors. The more saline lakes have grey cracking clays and carry chenopods. Salt lake floors carry little vegetation. Lunettes comprise varying soils from clean sands, brown clayey sands, mixed sand to clay.

7. Biodiversity

7.1 Plant communities

Typical sandplain species include rosewood (*Heterodendrum oleifolium*), white cypress pine (*Callitris glaucophylla*), narrow-leaf hopbush (*Dodonea viscosa*), punty bush (*Cassia eremophila*), belah, copperburrs (*Sclerolaena* sp.), black bluebush (*Maireana pyramidata*) and variable spear grass. The dunes support diverse mallee (*Eucalyptus* sp.) communities with mixed shrubs and porcupine grass (*Triodia pungens*). Belah (*Casuarina pauper*), rosewood and variable spear grass (*Stipa variabilis*) occupy the swales.

Lakes and depressions all have clay floors, and vegetation relates to the presence or absence of salt and gypsum. Infrequently flooded freshwater lakes carry cane grass (*Eragrostis australasica*), lignum (*Muehlenbeckia cunninghamii*) and nitre goosefoot (*Chenopodium nitrariaceum*), with clumps of black box (*Eucalyptus largiflorens*) on the margins.

The vegetation on lunettes varies. Clean sands often have white cypress pine, while brown clayey sands support mallee with porcupine grass. Mixed sand and clay lunettes carry rosewood, belah, western pittosporum (*Pittosporum phylliraeoides*), narrow-leaf hopbush and bluebush.

The largest rocky hills, Maccullochs Range, carry mulga (*Acacia aneura*) dominated vegetation very similar to much of the Cobar Peneplain. Smaller hills have more of a mixture of local sandplain species and distant rocky slope species.

7.2 Significant flora

Stipa nullanulla, now *Austrostipa nullanulla*, has been identified as regionally endemic to the Murray Darling Depression Bioregion and is listed as endangered in the TSC Act 1995 (Bowen and Pressey 1993, cited in Morton *et al.* 1995).

Significant flora species in the bioregion include *Austrostipa metatoris*, Mossgiel daisy (*Brachycome papillosa*), *Atriplex infrequens*, and *Swainsona pyrophila*, all listed as vulnerable in NSW. The bioregion also supports irongrass (*Lomandra patens*), found mainly within the Cobar Peneplain Bioregion, desert carpet-weed (*Glinus orygioides*), found mainly in the far northwest, bluebush daisy (*Cratystylis conocephala*), which is very rare in NSW, *Olearia calcarea*, found only near White Cliffs, sand cress (*Pachymitus cardaminoides*), *Indigofera helmsii* and Menindee nightshade (*Solanum karsensis*) (Bowen and Pressey 1993, cited in Morton *et al.* 1995, Cunningham *et al.* 1981).

Other significant species are the salt pipewort (*Eriocaulon australasicum*) and *Codonocarpus pyramidalis* (Fox 1991, cited in Morton *et al.* 1995) as well as *Atriplex papillata* near salt lakes and the yellow Darling pea (*Swainsona laxa*). These are considered to be relict populations and rare in NSW, although *S. laxa* also occurs near Menindee in the Darling Riverine Plains Bioregion (Cunningham *et al.* 1981).

Photo: NPWS

Photo: G. Bridle

7.3 Significant fauna

The malleefowl (*Leipoa ocellata*), which is listed as endangered in the TSC Act, is found throughout western NSW, including in the Murray Darling Depression Bioregion (Priddel 1990, Garnett 1992, cited in Morton *et al*. 1995). The plains-wanderer (*Pedionomus torquatus*), listed as vulnerable in the TSC Act, is found in this bioregion as well as in the Riverina Bioregion (Baker-Gabb *et al*. 1990, Garnett 1992).

Black-eared miners (*Manorina melanotis*) are listed as endangered in both state and Commonwealth legislation, as they are at great risk of extinction and, within NSW, are now found only in the Murray Darling Depression Bioregion (Garnett 1992, cited in Morton *et al*. 1995). The preferred habitat of the black-eared miner is dense, undisturbed old-growth mallee, which has undergone widespread clearing in NSW since the arrival of European settlers. This has resulted in the species occupying more open habitat, which is the preference of the yellow-throated miner (*Manorina flavigula*). This in turn has promoted cross-breeding between the two species, reducing the occurrence of pure forms of the black-eared miner (NSW NPWS 1999a).

The endangered eastern subspecies of the regent parrot (*Polytelis anthopeplus ssp. anthopeplus*) is generally confined to areas where mallee occurs adjacent to riverine woodlands in both the Murray Darling Depression and Riverina bioregions (NSW NPWS 1999b). With an estimated NSW population of about 500 individuals, the species is considered to be at risk due to loss of potential nesting trees with the clearing of river red gum (*Eucalyptus camaldulensis*) and mallee communities (NSW NPWS 1999b, Morton *et al*. 1995). Bush thick-knees (*Burhinus grallarius*) are also considered to be at risk in the bioregion (Morton *et al*. 1995).

Although known to occur across most of NSW, the freckled duck (*Stictonetta naevosa*) is recorded as breeding in the wetlands of the Great Cumbung Swamp and Lowbidgee Floodplain in the Murray Darling Depression Bioregion and other nearby bioregions (Morton *et al*. 1995). Many waterbirds in the bioregion and species such as the azure kingfisher (*Alcedo azurea*) are reported to be of conservation concern because of changes in their habitats (Morton *et al*. 1995).

Birds of the chenopod shrublands in the bioregion seem to be at risk of decline (Reid and Fleming 1992, cited in Morton *et al*. 1995).

Most of the extant eastern mallee (*Eucalyptus* sp.) and its former range (now mostly wheatfields) lies in the Murray Darling Depression Bioregion. There are several large and many small mallee remnants in the bioregion. Three bird species are found mostly or entirely in the long unburnt mallee in this bioregion; the red-lored whistler (*Pachycephala rufogularis*), the vulnerable mallee emu-wren (*Stipiturus mallee*) and the endangered black-eared miner (*Manorina melanotis*).

Major populations of the endangered eastern subspecies of regent parrot (*Polytelis anthopeplus*), which moves between mallee and river red gum vegetation, are found in the bioregion. The western whipbird (*Psophodes nigrogularis*), the vulnerable malleefowl (*Leipoa ocellata*) and the endangered plains wanderer (*Pedionomus torquatus*), the range of which is centred on the Riverina, can also be found. More than 4% of birds observed in the bioregion are exotic species, including the Eurasian skylark (*Alauda arvensis*), European goldfinch (*Carduelis carduelis*) and the common starling (*Sturnus vulgaris*), all of which have adapted well to the agricultural landscapes of the bioregion.

Numbers of the musk lorikeet (*Glossopsitta concinna*) have increased in the bioregion, as have temperate forest and temperate woodland birds. Conversely, grassland, ground-nesting birds and ground-feeding insectivorous species have decreased in numbers. The general trend in this bioregion is a gradual decline in numbers in isolated habitat fragments, and extinctions that occur in major mallee blocks during rare, large-scale fires. The future of many bird populations in the bioregion may be dependent on appropriate fire management as well as the restoration, expansion and linking of habitat fragments.

The skink (*Ctenotus brachyonyx*) inhabits spinifex grasslands in the Murray Darling Depression and Simpson-Strzelecki Dunefields bioregions in NSW and also occurs in Qld. Populations of the elapid snake (*Notechis scutatus*) are declining in riverine habitats along the Murray-Darling system, while the python (*Morelia spilota variegata*) also appears to be declining in several vegetation types (Sadlier and Pressey 1994, cited in Morton *et al*. 1995). The distribution of the southern bell frog (*Litoria raniformis*) seems to be retracting from its northwestern limit (Sadlier and Pressey 1994, cited in Morton *et al*. 1995).

7.4 Significant wetlands

The Darling Anabranch Lakes provide large areas of habitat for waterbirds when inundated (ANCA 1996). The lakes are considered to be in a fair condition, although they are declining due to changed hydrology caused by salinity, water abstraction and regulation, weir construction upstream, construction of levee banks and lake bed cropping.

The Lowbidgee Floodplain has also been described as degraded although it provides an important refuge when other wetlands are dry, and it supports breeding colonies of Australian white ibis (*Threskiornis molucca*), glossy ibis (*Plegadis facinellus*), straw necked ibis (*Threskiornis spinicollis*), royal spoonbill (*Platalea regia*), great egret (*Casmerdius albus*) and intermediate egret (*Egretta intermedia*) (ANCA 1996).

Conoble Lake is a significant wetland of the bioregion, and is predicted to be able to support 11,000 waterbirds. There have been many sightings of the vulnerable Major Mitchell's cockatoo (*Cacatua leadbeateri*) near Conoble Lake, while two endangered plants, *Kippistia suaedifolia* and *Dysphania plantaginella*, have also been recorded.

Lake Victoria supports the endangered southern bell frog (*Litoria raniformis*), the vulnerable Major Mitchells Cockatoo and the endangered regent parrot (Australian Terrestrial Biodiversity Assessment 2002), as well as providing habitat for 20,000 waterbirds (Kingsford *et al.* 1997).

The Willandra Creek and Lakes is one of the most significant wetland areas in the bioregion, supporting a variety of threatened species even though it has been described as being in a degraded condition and declining (Australian Terrestrial Biodiversity Assessment 2002). Many sightings have been recorded here including the blue-billed duck (*Oxyura australis*), freckled duck (*Stictonetta naevosa*), black-breasted buzzard (*Hamirostra melanosternon*), Australasian bittern (*Botaurus poiciloptilus*), Major Mitchells cockatoo, painted honeyeater (*Grantiella picta*), barking owl (*Ninox connivens*), little pied bat (*Chalinolobus picatus*), inland forest bat (*Vespadelus baverstocki*), stripe-faced dunnart (*Sminthopsis macroura*), long-haired rat (*Rattus villosissimus*), slender darling pea (*Swainsona murrayana*) and mossgiel daisy (*Brachyscome papillosa*). Endangered species found at Willandra Creek include the southern bell frog (*Litoria raniformis*), Australian bustard (*Ardeotis australis*) and plains wanderer (*Pedionomus torquatus*) (Australian Terrestrial Biodiversity Assessment 2002).

Two other wetlands, which provide significant habitat for waterbirds but are currently described as being in a degraded condition are Gunnaramby Swamp and Moornanya Lake.

Gol Gol Lake (Benanee) lies partly in the Murray Darling Depression Bioregion but occurs mostly within the Riverina. Nettlegoe Lake and Poopelloe Lake fall partly in the bioregion but mainly in the Darling Riverine Plains Bioregion.

Threats to wetlands in the Murray Darling Depression Bioregion include feral animals, exotic weeds, salinity, water abstraction and regulation, and regulation producing perennial flooding (National Biodiversity Audit).

8. Regional history

8.1 Aboriginal occupation

For information on the Aboriginal occupation of the Murray Darling Depression Bioregion, refer to Chapter 1 under the heading "Regional history".

8.2 European occupation

Ivanhoe, the main town of the Murray Darling Depression Bioregion, was established after the first land was sold at the town in 1869. In 1870, Cobb and Co Coaches opened routes through Ivanhoe, and the town continued to develop, first with a general store and then with a post office. Police were present in Ivanhoe from 1879 to protect the public from the local Hatfield Bushrangers and by 1885 the mounted police had arrived. This same year the Ivanhoe Jockey Club held its first race meeting. The first bank opened in 1926 and the railway reached Ivanhoe in 1927, an important addition to the town as water could now be carried from nearby lakes from where it had previously been carted by dray. The pubs of Ivanhoe were an important part of the town, bringing visitors to stop in the town on their way. As in other bush towns, the development of bush pubs occurred along the route of the mail coaches, and their need for watering points – both for themselves and their horses.

The main land use around Ivanhoe in the 1870s was sheep and stations such as Kilfera, which employed close to 200 people at shearing time when 8,000 sheep per day were shorn. The station carried up to 200,000 merino sheep on its 832,000 acres.

9. Bioregional-scale conservation

Conservation management in the Murray Darling Depression Bioregion is achieved through a range of conservation mechanisms that together occupy about 421,082 ha or 5.25% of the bioregion.

Mechanisms provided for under the NPW Act 1974, and specifically national parks and nature reserves, are responsible for the majority of land conserved. Mallee Cliffs and Mungo National Parks (NPW Act 1974) both lie wholly within the bioregion. Eight nature reserves occur either partially or wholly within the bioregion and together with the national parks occupy 279,343 ha or 3.48% of the bioregion. None of the reserves in the bioregion is also managed as wilderness areas under the Wilderness Act 1987, although the Willandra Lakes Region is included on the globally recognised World Heritage list as one of three world heritage areas in NSW. Occupying approximately 240,000 ha or almost 3% of the bioregion, the Willandra Lakes region is protected by international convention as well as by the Commonwealth EPBC Act 1999, which automatically protects all Australian properties that are on the World Heritage List. About 10% of the Willandra Lakes Region World Heritage area is in Mungo National Park, which covers about two-thirds of Lake Mungo. Despite its name, the world heritage area is not within Willandra National Park in the Riverina Bioregion.

There are no Aboriginal areas, no historic sites, no state recreation areas and no regional parks in the bioregion. No voluntary conservation agreements or property agreements have been entered into with landholders, although 9 wildlife refuges are held by landholders and occupy about 1.76% of the bioregion.

A small proportion (0.07%) of the bioregion is managed as State forests for a range of forestry practices under the Forestry Act 1916, including timber production and forest management. There are 10 State Forests managed primarily for forestry activities and one flora reserve (Peacock Creek Flora Reserve) which occupies 0.001% of the bioregion and spans the border with the Riverina Bioregion.

Photo: NPWS

10. Subregions of the Murray-Darling Depression Bioregion

(Morgan and Terrey 1992)

Subregion -	Geology	Characteristic landforms	Typical soils	Vegetation
South Olary Plain	Quaternary aeolian sands and lake sediments.	Dunefields, sandplains, dry lakes and groundwater basins.	Deep siliceous and calcareous red to yellow sands, sandy earths, brown texture contrast soils on dunes and sandplains. Saline, gypseous and calcareous clays on lake beds, mixed sands and pelleted clays in lunettes.	Diverse mallee on sands with; pointed mallee, congoo mallee, red mallee, lerp mallee, slender-leaf mallee, yorrell, white cypress pine, mallee cypress pine, belah, rosewood, with porcupine grass and diverse shrubs. Belah, rosewood, black bluebush, pearl bluebush, old man saltbush, on sandplains and heavier soils. Black box fringing depressions, halophytes on salinas, and chenopod shrublands on lunettes, sometimes with white cypress pine.
Darling Depression	Quaternary aeolian sands and lake sediments. Isolated Devonian quartz sandstone outcrops.	Extensive sandplains. Dunefields piled against Cobar Peneplain ranges. freshwater overflow lakes fed by rare floods in the Darling River. Stony ridges and ranges.	Deep siliceous and calcareous red to yellow sands, sandy earths, brown texture contrast soils on dunes and sandplains. Brown and grey and calcareous clays on lakes. Pale yellow sands on lunettes. Stony loams on hills.	Belah, rosewood, nelia, mulga wilga and woody shrubs on western sandplains. Pointed mallee, congoo mallee, yorrell with diverse shrubs and porcupine grass, occasional kurrajong and mallee cypress pine on eastern sandplains. Mulga, white cypress pine, red box, mallee, belah and poplar box on central dunes. Lignum, canegrass, black bluebush and black box or poplar box on margins and beds of swamps and lakes. Mulga with red box and shrubs on rocky hills.

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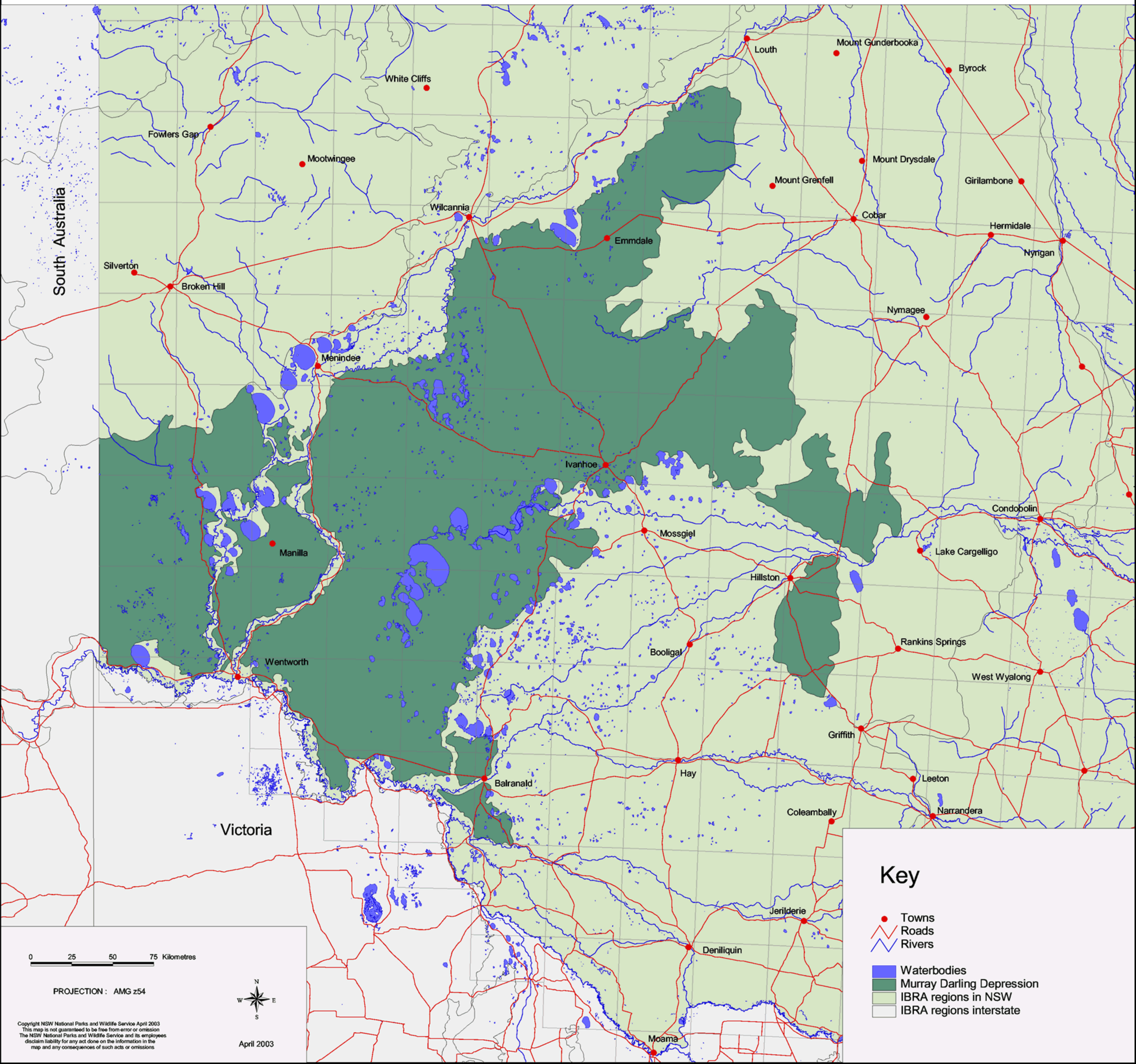
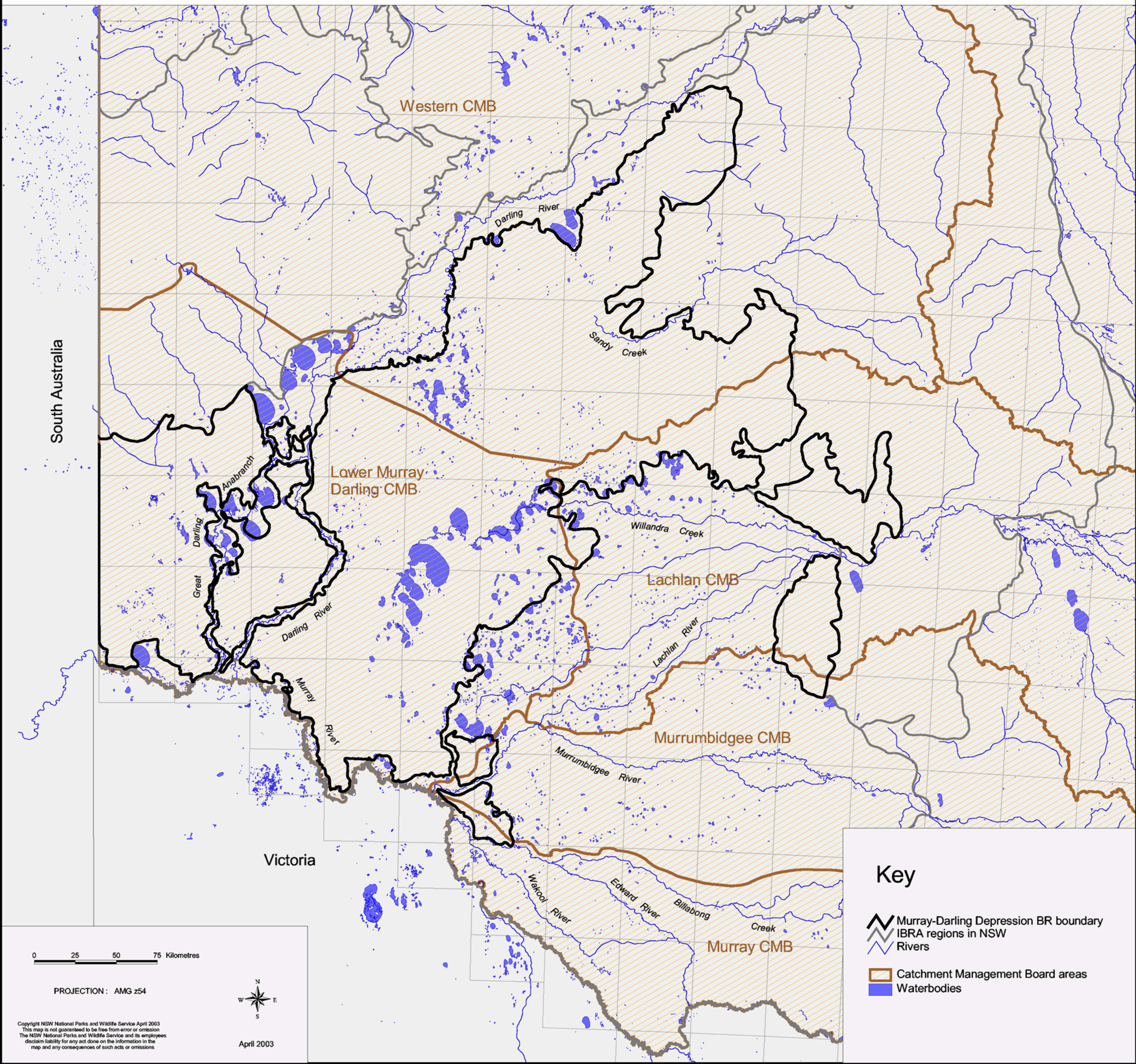
Website

http://www.outbacknsw.org.au/ivanhoe.htm

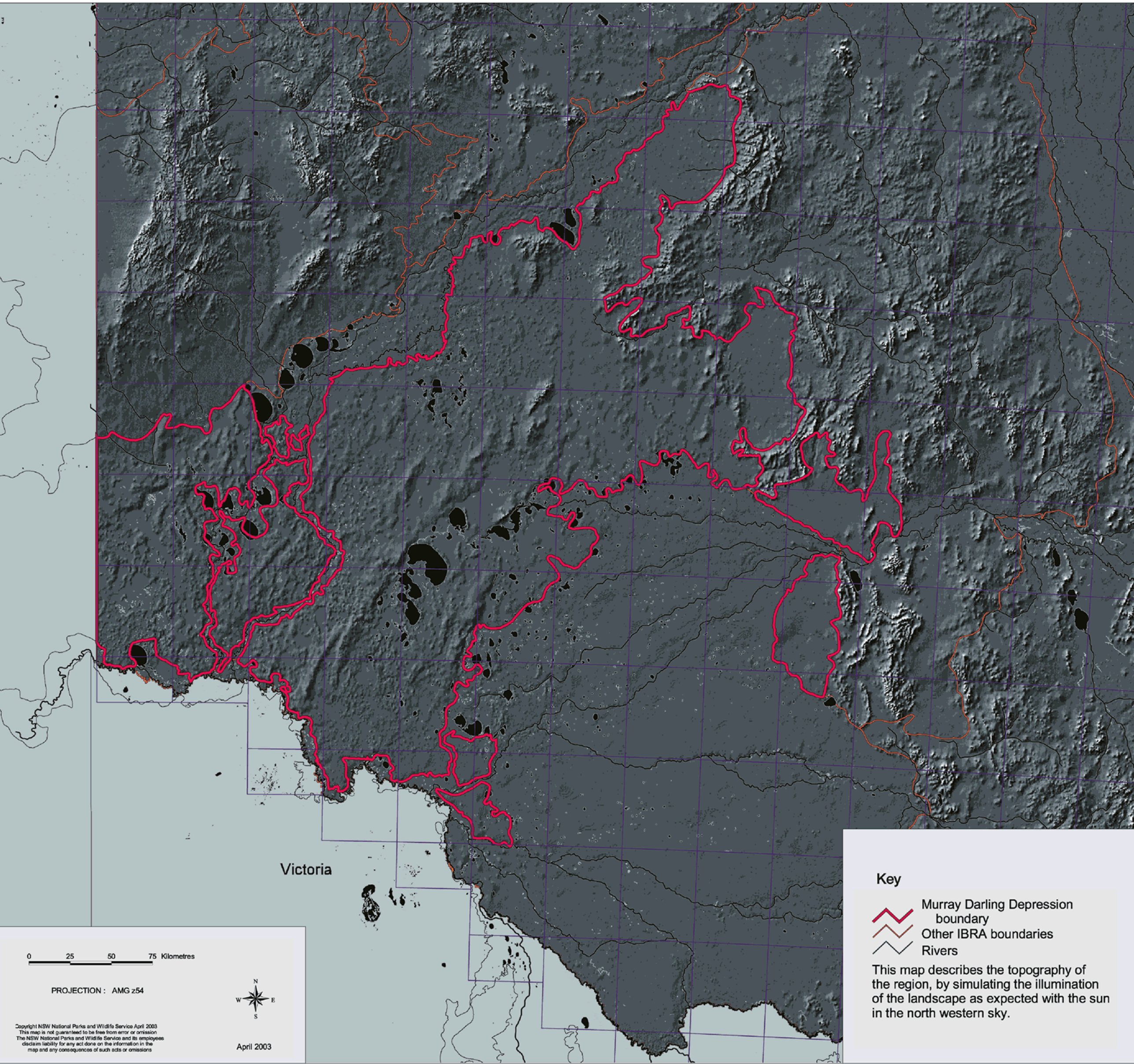
Murray-Darling Depression Biogeographic Region (IBRA) - Location



Murray-Darling Depression Biogeographic Region (IBRA) - Rivers



Murray Darling Depression Biogeographic Region (IBRA) - Topography



0 25 50 75 Kilometres

PROJECTION : AMG z54

N
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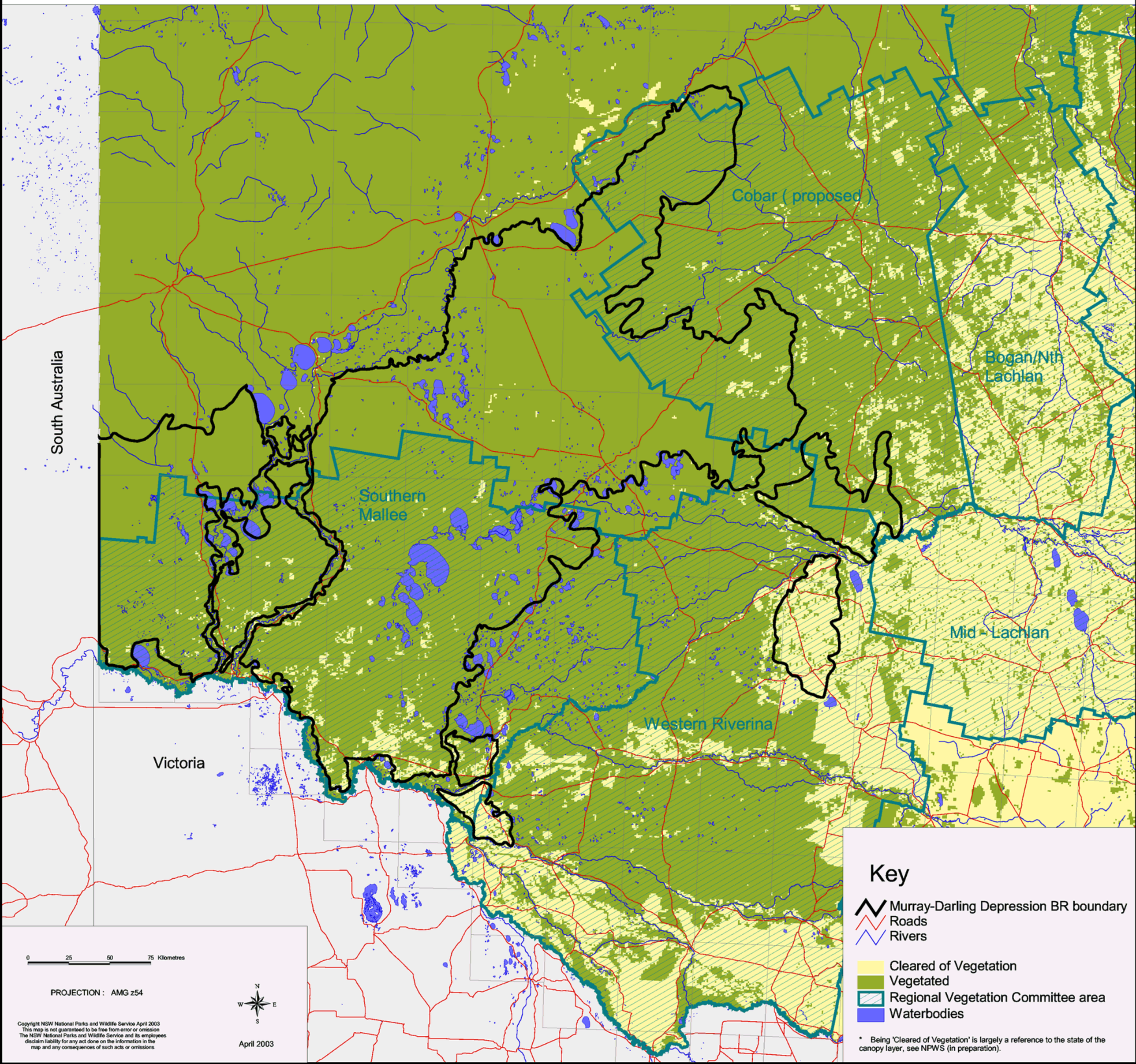
April 2003

Key

Murray Darling Depression boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

Murray-Darling Depression Biogeographic Region (IBRA) - Vegetation



Murray - Darling Depression Biogeographic Region (IBRA) - Tenure/Reserves

South Australia

Victoria

Key

- Murray-Darling Depression BR boundary
- IBRA regions in NSW
- Roads
- Rivers
- Waterbodies
- Wilderness (declared)
- Service Estate
- on other tenure
- NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area
- Other tenure
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

0 25 50 75 Kilometres

PROJECTION : AMG z54

N W E S

April 2003

Murray-Darling Depression Biogeographic Region (IBRA) - Subregions and Landscapes (Mitchell, in preparation)

Key

Subregion boundaries (IBRA)

Murray-Darling Depression (IBRA)

Landscapes of the Murray-Darling Depression

- Barnato Downs
- Barnato Incised Streams
- Barnato Isolated Bedrock Hills
- Barnato Isolated Lakes
- Barnato Linear Dunes
- Barnato Plains
- Barnato Wide Valleys
- Barrier Alluvial Plains
- Barrier Salt Lakes and Playas
- Barrier Sandplains
- Belarabon Range
- Bokara Hills
- Buckambool-Jackermaroo Hills
- Cocoparra Ranges and Footslopes
- Gilgunnia-Broken Ranges
- Ivanhoe-Nangara Alluvial Plains
- Ivanhoe-Nangara Dunes
- Ivanhoe-Nangara Fresh Lakes and Swamps
- Ivanhoe-Nangara Isolated Bedrock
- Ivanhoe-Nangara Linear Dunes
- Ivanhoe-Nangara Relic Lakes
- Ivanhoe-Nangara Salt Lakes and Playas
- Ivanhoe-Nangara Sandplains
- Lachlan Channels and Floodplains
- Lachlan Depression Plains
- Lachlan Lakes, Swamps and Lunettes
- Lachlan Sandplains
- Lachlan Scalded Plains
- Lachlan Source-bordering Dunes
- Lower Darling Alluvial Plains
- Lower Darling Channels and Floodplains
- Lower Darling Lakes and Swamps
- Lower Darling Salt Lakes and Playas
- Maccullochs Range
- Mallee Cliffs Dunes
- Mallee Cliffs Linear Dunes
- Mallee Cliffs Relic Lakes
- Mallee Cliffs Salt Lakes and Playas
- Mallee Cliffs Sandplains
- Marma Hills
- Mid Darling Alluvial Plains
- Mid Darling Channels and Floodplains
- Mid Darling Lakes and Swamps
- Mt Grenfell Complex
- Mungo Lakes Complex
- Mungo-Marona Dunes
- Mungo-Marona Lakes and Swamps
- Mungo-Marona Linear Dunes
- Mungo-Marona Relic Lakes
- Mungo-Marona Sandplains
- Murray Channels and Floodplains
- Murray Lakes, Swamps and Lunettes
- Murray Sandplains
- Murrumbidgee Channels and Floodplains
- Murrumbidgee Depression Plains
- Murrumbidgee Lakes, Swamps and Lunettes
- Murrumbidgee Sandplains
- Murrumbidgee Scalded Plains
- Nangarybone Hills
- Neckarbo Range
- Nymagee Downs
- Nymagee Granite Downs
- Nymagee Isolated Bedrock Hills
- Nymagee Isolated Lakes
- Nymagee Sandplains
- Nymagee Wide Valleys
- Sayers Lake Complex
- Scotia Dunes
- Scotia Groundwater Basins
- Scotia Linear Dunes
- Scotia Sandplains
- Scotts Craig Hills
- Shepherds Hill and Footslopes
- Waranary-Yathong Ranges

Other Landscapes

IBRA regions interstate

0 25 50 75 Kilometres

PROJECTION : AMG z54

April 2003

CHAPTER 8

The Riverina Bioregion

1. Location

The Riverina Bioregion lies in southwest NSW, extending into central-north Vic. The bioregion is approximately 9,576,964 ha, with 7,090,008 ha or 74.03% of it lying in NSW (IBRA 5.1). The NSW portion of the bioregion occupies approximately 8.86% of the State (Eardley 1999 and IBRA 5.1).

The Riverina Bioregion extends from Ivanhoe in the Murray Darling Depression Bioregion south to Bendigo, and from Narrandera in the east to Balranald in the west. Within its boundaries lie the towns of Hay, Coleambally, Deniliquin, Leeton, Mossgiel, Hillston, Booligal and Wentworth, while Griffith, Ivanhoe, Narrandera and Albury lie just outside its boundary in neighbouring bioregions. The bioregion also includes outlying remnants of the Murray Darling Depression Bioregion in its western boundary, and the Victorian Midlands Bioregion in the south.

The Murray and Murrumbidgee Rivers and their major tributaries, the Lachlan and Goulburn Rivers, flow from the highlands in the east, westward across the Riverina plain.

2. Climate

The Riverina Bioregion is one of 6 NSW bioregions lying in a central band of the state dominated by a persistently dry semi-arid climate, and characterised by hot summers and cool winters (Stern *et al.* 2000). Seasonal temperatures vary little across the bioregion, although in the north both summer and winter temperatures tend to be higher (Eardley 1999).

The highest levels of rainfall in the Riverina Bioregion occur in May and September (Eardley 1999). Summer rainfall tends to occur mainly from localised thunderstorms, with more consistent rainfall occurring in the winter months. Annual rainfall tends to increase from west to east and from north to south. The occurrence of rainfall is unpredictable toward the northwest of the bioregion, and drought periods are not unusual (Dalton 1988, cited in Eardley 1999). Minor areas of the Riverina extend into climatic zones other than the hot semi-arid climate at the core of the bioregion. The northern tip characterises a warm semi-arid climate while the southeastern edge of the bioregion at the boundary of the neighbouring South Western Slopes Bioregion lies in the subhumid climatic zone (Stern *et al.* 2000).

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
15 – 18°C	2.2 – 4.6°C	30.6 – 33.7°C	238 – 617mm	13 – 36mm	26 – 70mm

3. Topography

The Riverina covers the alluvial fans of the Lachlan, Murrumbidgee and Murray Rivers west of the Great Dividing Range and extends down the Murray. Much of the geology and geomorphology of the region is similar to that of the Darling Riverine Plains Bioregion. The upper catchment landscape is a series of overlapping, low gradient alluvial fans. The lower tract of the river is a floodplain with overflow lakes. Discharge from past and present streams control patterns of sediment deposition, soils, landscapes and vegetation.

4. Geology and geomorphology

This bioregion is dominated by river channels, floodplains, backplains, swamps, lakes and lunettes that are all of Quaternary age. The region comprises three overlapping alluvial fans centred on the eastern half of the Murray Basin. Features of each fan differ slightly because of differences in the discharge of the streams. The Lachlan fan is mainly clay as this smaller stream does not have the competence to carry sand. The other two fans are similar except that the Murray is more confined and has more active anabranch channels where it is forced to flow around the obstacle of the Cadell fault near Echuca. At times of extreme flood flow, water from the different streams can cross the fan surfaces and enter channels of another system.

The evolutionary story of these fans is one of decreasing discharge through time that parallels the story of the Darling Riverine Plain. Different phases of stream discharge have been linked to prior and ancestral stream patterns each with different form and different bed load characteristics. Between 15-30,000 years ago, prior streams carried sand far onto the clay plains in wide channels with long meanders. Ancestral streams are more like the modern channels, with tighter meanders and carrying only clay. Alluvial sediments become deeper and older in the western half of the basin, reaching a maximum thickness of about 500m. Basement rocks are the early Palaeozoic sediments and granites of the Lachlan Fold belt, but almost no outcrops exist in the Riverina.

As in the Darling Riverine Plains, three types of wetland are found: delta-like swamplands particularly on the Lachlan, terminal drainage basins and lakes on Willandra Creek and overflow lakes on the Murray. Lake beds are covered by grey cracking clays and the eastern margins of most lakes have well-formed sandy beaches and crescent-shaped dunes or lunettes up to 25m high and composed of fine cemented quartz sand with some layers of pelleted clay. Older, abandoned lakes are also widespread.

5. Geodiversity

Important features of this bioregion include the following:

- evidence of changed Quaternary environments and human history is preserved in the landscape patterns of prior streams, lake beds and lunettes;
- coarse sand in prior stream beds is an important economic resource in a region without rock outcrop; and
- the wetlands of this bioregion are very important habitats in southern inland regions of the state.

6. Soils

Modern river channels consist mostly of sandy soils and more saline heavy grey and brown clays towards the outer perimeter of the floodplains on the higher rarely flooded terraces (Eardley 1999). Sandy soils also form levees, old channels, dunes and lunettes.

As soil and water salinity increase downstream on the Murrumbidgee, saline clays become evident on lake floors.

The red-brown and grey clays in the bioregion support grassland communities that are nationally significant. Calcareous, sandy soils, that tend to be feature of adjacent bioregions are also present in the Riverina and support mallee communities (Semple 1990, Porteners 1993, cited in Eardley 1999).

7. Biodiversity

7.1 Plant communities

Modern river channels support river red gum (*Eucalyptus camaldulensis*) and river cooba (*Acacia stenophylla*) communities. Here on the sandy soils, the river red gum understorey is generally composed of herbaceous perennial, annual and post-flooding ephemeral species that alter with topography and flooding characteristics (Eardley 1999).

Nearby on the higher, more saline heavy grey and brown clays towards the outer perimeter of the floodplains, black box (*Eucalyptus largiflorens*) woodlands dominate with an understorey of salt-tolerant grasses, saltbushes and daisies (Eardley 1999).

On the highest, rarely flooded terraces, yellow box (*Eucalyptus melliodora*) communities occur along with cypress pine and grey box (*Eucalyptus microcarpa*) (Eardley 1999).

Further from the rivers, many plains are treeless and carry saltbush shrubland, composed of old man saltbush (*Atriplex nummularia*), bladder saltbush (*Atriplex vesicaria*), cotton bush (*Maireana aphylla*) and native grasslands (*Danthonia spp* and *Stipa spp*) (Eardley 1999). A formerly extensive community of myall (*Acacia pendula*) shrubland and old man saltbush on the backplains has almost vanished (Mitchell in prep).

Sandy soils on levees, old channels, dunes and lunettes have stands of white cypress pine (*Callitris glaucophylla*), sometimes with mallee and bluebush (*Maireana* sp.). Lake beds may be bare or covered by clumped lignum (*Muehlenbeckia cunninghamii*) with a fringe of black box. Next to rivers and creeks, shrublands of lignum (*Muehlenbeckia florulenta*) and nitre goosefoot (*Chenopodium nitrariaceum*) dominate the flats and low-lying swamps (Eardley 1999). Swamps have wide margins of river red gum, black box and, depending on water depth, also support the common reed (*Phragmites australis*), cumbungi (*Typha* sp.), grasses and floating water plants.

As soil and water salinity increase downstream and saline clays become evident on lake floors, salt-tolerant species such as samphire (*Arthrocnemum* sp.) become common.

Although less characteristic of the Riverina, belah (*Casuarina cristata*) – rosewood (*Alectryon oleifolius*) and mallee (*Eucalyptus socialis, E. dumosa*) communities are common on the bioregional boundary. Mallee occurs on the calcareous, sandy soils that tend to be a feature of adjacent bioregions (Semple 1990, Porteners 1993, cited in Eardley 1999).

The Riverina Bioregion includes the *Acacia loderi* shrublands endangered ecological community listed under the TSC Act 1995.

7.2 Significant flora

The Riverina grassland communities that occur on red-brown and grey clays are nationally significant because the lowland grasslands of southeastern Australia are significantly threatened and also poorly conserved (Eardley 1999). These communities support a number of threatened plant species such as the endemic red Swainson pea (*Swainsona plagiotropis*) as well as

Swainsona murrayana, Sclerolaena napiformis, Brachycome chrysoglossa and *Lepidium monoplocoides* (Eardley 1999).

Twenty-eight threatened species from the Riverina Bioregion are listed in the schedules of the TSC Act (NSW NPWS 2001). Twelve of these are listed as endangered, 15 are listed as vulnerable and one species, *Tetratheca pilosa ssp. pilosa,* is considered extinct in the bioregion.

A member of the chenopod family, *Maireana cheelii* or chariot wheels, is listed as threatened in the NSW TSC Act as well as the Commonwealth EPBC Act. This species is restricted to the riverine plain of NSW, generally in the vicinity of Deniliquin and Hay, and therefore can be considered endemic to the Riverina Bioregion. The main areas of shrublands in NSW occur on the riverine plain (Cunningham *et al.* 1981).

7.3 Significant fauna

Significant fauna known to occur in the riverine forests of the Riverina Bioregion include the superb parrot (*Polytelis swainsonii*), sugar glider (*Petaurus breviceps*), feathertail glider (*Acrobates pygmaeus*), squirrel glider (*Petaurus norfolcensis*), brush-tailed phascogale (*Phascogale tapoatafa*), koala (*Phascolarctos cinereus*), carpet python (*Morelia spilota*), freckled duck (*Stictonetta naevosa*) and peregrine falcon (*Falco peregrinus*) (Eardley 1999).

Black box woodlands provide significant habitat to a diversity of bird species including the bush thickknee (*Burhinus magnirostris*) and the superb parrot, which will only nest where box woodland occurs within 10 km of selected nest trees (usually river red gum) (Eardley 1999).

Species including the plains-wanderer (*Pedionomus torquatus*), bush thicknee, striped legless-lizard (*Delmar Impar*) and fat-tailed dunnart (*Sminthopsis crassicaudata*) are found in the shrublands and grasslands of the Riverina Bioregion (Eardley 1999).

The northern hairy-nosed wombat (*Lasiorhinus krefftii*) was once found throughout southwestern NSW, particularly in the Riverina Bioregion. However, competition with cattle, sheep and rabbits has led to the rapid decline of the species (Strahan 1983) and the wombat is now presumed extinct, listed in Schedule 1 part 4 of the TSC Act.

As with other areas of western NSW, birds of the chenopod shrublands in the bioregion seem to be at risk of decline (Reid and Fleming 1992, cited in Morton *et al.* 1995).

The plains-wanderer (*Pedionomus torquatus*) is listed as endangered in the TSC Act and vulnerable in the EPBC Act, and although it is also found in the Murray Darling Depression Bioregion, the core of the range of this ground bird falls in the Riverina Bioregion. The species is largely confined to patches of sparse grassland and areas with low, open vegetation, often where the light topsoil is affected by wind erosion (NSW NPWS 1999). Conservation of this species is dependent on effective habitat management so as to avoid intensive cultivation, burning or overgrazing (Morton *et al.* 1995).

The endangered trout cod (*Maccullochella macquariensis*) is endemic to the section of the Murray-Darling system that lies in the Riverina Bioregion. The distribution of the Macquarie perch (*Macquaria australasica*) has declined to such an extent that its range is now restricted to the Murrumbidgee and Lachlan Rivers in the Riverina Bioregion (Morton *et al.* 1995) where previously it was widespread across the Murray-Darling River system. This decline is a

Photo: NPWS

common trend among the 29 species of fish found within the Murray-Darling system (Morton *et al.* 1995), including the two-spined blackfish (*Gadopsis bispinosus*), Murray jollytail (*Galaxias rostratus*), Australian rainbowfish (*Melanotaenia fluviatilis*), Murray cod (*Maccullochella peeli*) and silver perch (*Bidyanus bidyanus*).

The effect of clearing and grazing, coupled with competition from introduced herbivores such as sheep and rabbits and the impact of carnivores such as foxes and cats, has resulted in a general decrease in the number and species of flora and fauna in the bioregion. Small mammals such as the now rare bridled nail-tail wallaby (*Onychogalea fraenata*) and the extinct eastern hare-wallaby (*Lagorchestes leporides*) are obvious victims of both habitat modification and competition (Eardley 1999).

7.4 Significant wetlands

Important wetlands, which can support more than 20,000 waterbirds, occur in the Murrumbidgee-Lachlan confluence, Barmah-Millewa Forest, and Edward and Murrumbidgee River floodplains (Kingsford *et al.* 1996, cited in Eardley 1999). Many of these waterbirds are migratory and several, such as the Australasian bittern (*Botaurus poiciloptilus*), freckled duck and painted snipe (*Rostratula benghalensis*), are listed as vulnerable under the TSC Act (Eardley 1999).

Eight wetlands have been identified as having bioregional significance in the Riverina (Australian Terrestrial Biodiversity Assessment 2002).

Lake Urana provides habitat for the endangered winged peppercress (*Lepidium monoplocoides*) which is mainly found on the shores of the lake. Both the vulnerable freckled duck (*Stictonetta naevosa*) and the vulnerable brolga (*Grus rubicundus*) have been recorded here (NSW NPWS 2001a). Modelling has suggested that the Lake could support 11,000 waterbirds (Kingsford *et al.* 1997).

Loorica Lake supported almost 17,000 waterbirds in 1987, including the grey teal (*Anas gracilis*), hardhead (*Aythya australis*) and whiskered tern (*Sterna hybrida*) (Australian Terrestrial Biodiversity Assessment 2002). In 1983, Loorica Lake provided nesting habitat for the black swan (*Cygnus atratus*) (Australian Terrestrial Biodiversity Assessment 2002). The vulnerable freckled duck, blue-billed duck (*Oxyura australis*) and black-tailed godwit (*Limosa limosa*) have also been recorded (NSW NPWS 2001). The black-tailed godwit, found at the Lake, is listed on the China-Australia Migratory Bird Agreement (CAMBA) and the Japan-Australia Migratory Bird Agreement (JAMBA) (NSW NPWS 2001).

An unnamed swamp southeast of Lake Tala supported more than 20,000 waterbirds in 1983, including the grey teal (*Anas gracilis*), pink-eared duck (*Malacorhynchus membranaceus*) and Eurasian coot (*Fulica atra*). In 1986 and 1987, 7,000 waterbirds were present in the swamp. In 1983 and 1988, the black swan (*Cygnus atratus*) used the swamp as a nesting site. The freckled duck has also been recorded here.

Gol Gol Lake is significant to this bioregion and also extends into part of the Murray Darling Depression Bioregion. The lake provides habitat for the endangered southern bell frog (*Litoria raniformis*) as well as many vulnerable species including the painted snipe (*Rostratula benghalensis*), freckled duck and square-tailed kite (*Lophoictinia isura*) (NSW NPWS 2001).

Another significant wetland in the bioregion is the Edward River Floodplain, with wetland modelling predicting that it could support 54,000 waterbirds (Kingsford *et al.* 1997). The vulnerable brolga (*Grus rubicundus*) and Major Mitchells cockatoo (*Cacatua leadbeateri*) have been recorded at the wetland as has the painted honeyeater (*Grantiella picta*) (NSW NPWS 2001a).

The Tuppal Creek Floodplain supports a range of threatened species including the vulnerable koala (*Phascolarctos cinereus*), superb parrot (*Polytelis swainsonii*) and Australian bustard (*Ardeotis australis*) (MSW NPWS 2001a). The endangered bush stone-curlew (*Burhinus grallarius*) and the vulnerable square-tailed kite (*Lophoictinia isura*) have also been recorded here. Modelling has predicted that this floodplain could support 19,000 waterbirds (Kingsford *et al.* 1997).

Morrisons Lake is reserved within the Morrisons Lake Nature Reserve. The Lake provides habitat for a range of threatened species including the vulnerable Major Mitchells cockatoo, square-tailed kite, blue-billed duck (*Oxyura australis*), grey falcon (*Falco hypoleucos*), freckled duck (*Stictonetta*

Photo: NPWS

naevosa), Australasian bittern (*Botaurus poiciloptilus*) and painted snipe (*Rostratula benghalensis*).

Barrenbox Swamp has also been described as significant to the Riverina Bioregion. The swamp provides habitat for the vulnerable freckled duck, blue-billed duck, Australasian bittern (*Botaurus poiciloptilus*), painted snipe (*Rostratula benghalensis*) and magpie goose (*Anserenas semipalmata*) (NSW NPWS 2001). The painted snipe is protected under CAMBA. The endangered bush stone-curlew (*Burhinus grallarius*) (NSW NPWS 2001a) and the southern bell frog (*Litoria raniformis*) have also been recorded here.

The Booligal wetlands have also been recognised as a refuge for biodiversity in the bioregion (Morton *et al.* 1995).

The NSW Central Murray State Forests, together with the listed Ramsar wetlands in Victoria (Barmah and Gunbower forests), form the largest complex of tree-dominated floodplain wetlands in southern Australia. The site contains wetland types that are rare within the Riverina bioregion, particularly types floodplain lakes and floodplain meadows and reed swamps and regularly supports more than 20,000 waterbirds (eg. Mattingley 1908, Barrett 1931, Chesterfield *et al.* 1984, Maher 1993, Leslie and Ward in press).

The site plays a substantial role in the functioning of the Murray River, particularly in terms of hydrology flood mitigation, water quality sediment deposition and river health and has recently been nominated for Ramsar listing.

It provides a habitat network for at least 8 globally threatened fauna listed by the World Conservation Union in 2000. The Australasian bittern (*Botaurus poiciloptilus*), superb parrot (*Polytelis swainsonii*), silver perch (*Bidyanus bidyanus*) and flat-headed galaxias (*Galaxias rostrata*) are listed as "vulnerable", and the regent honeyeater (*Xanthomyza phrygia*), swift parrot (*Lathamus discolor*), Murray hardyhead (*Craterocephalus fluviatilis*) and trout cod (*Maccullochella macquariensis*) are listed as "endangered" on the IUCN Red List (2000).

The Central Murray State Forests are ecologically linked through an unbroken riparian corridor along the Murray and Edward Rivers. They are in high ecological condition and provide arboreal and wetland habitat in landscapes extensively cleared of trees and developed for agriculture. As such, the site contributes significantly to the conservation of globally and nationally threatened species. The site is immediately adjacent to other wetlands included in the Ramsar List of Wetlands of International Importance in the neighbouring state of Victoria, and thus, further enhances the viability of threatened flora and fauna species that occur at these Ramsar sites.

The area provides a habitat network for 13 species listed in migratory bird agreements between Australia, and Japan (JAMBA) and China (CAMBA). These species are painted snipe (*Rostralula benghalensis*), great egret (*Ardea alba*), cattle egret (*Ardea ibis*), sharp-tailed sandpiper (*Calidris acuminata*), greenshank (*Tringa nebularia*), marsh sandpiper (*Tringa stagnatilis*), Latham's snipe (*Gallinago hardwickii*), white-throated needletail (*Hirundapus caudacutus*), forked-tailed swift (*Apus pacificus*), glossy ibis (*Plegadis falcinellus*), Caspian tern (*Hydropogne caspia*), red-necked stint (*Calidris ruficollis*) and white-bellied sea-eagle (*Haliaeetus leucogaster*).

The wetlands of the Riverina Bioregion have been described as being in fair to degraded condition. Changed hydrology is a key threat to all of these wetlands, but there are also impacts from feral animals, exotic weeds, water extraction, regulation and diversion, altered nutrient levels, salinity, grazing pressure, reduced flows and use for water storage.

8. Regional history

8.1 Aboriginal occupation

It is thought that Aboriginal people have been present in the Murray-Darling Basin for at least 40,000 years (Hope 1995, cited in Eardley 1999). The Riverina Bioregion was the original homeland for many large Aboriginal communities that lived on the Hay Plain and around the rivers. These communities include the Wiradjuri, Nari-Nari, Mudi-Mudi, Gurendji and the Yida-Yida, while the Bangerang, Yorta-Yorta, Baraba-Baraba, Wamba-Wamba, Wadi-Wadi and Dadi-Dadi communities were found along the Murray River (NSW Department of Lands 1987, cited in Eardley 1999).

The rivers of the bioregion were central to the local Aboriginal lifestyles, especially as a source of food (Hope 1995, cited in Eardley 1999). It has been suggested that access to the water and its resources was a privilege inherited by generation after generation of certain groups (Pardoe 1988, cited in Eardley 1999). Unlike Europeans that have tended to use major rivers as administrative boundaries, the Aboriginal communities of the Riverina did not view the rivers as boundaries between language groups. Wiradjuri country straddled the Murrumbidgee, Bangerang country lay west from Albury to Moama on both sides of the Murray, and the Narinari occupied the land west of this.

The Bangerang people used the Murray River extensively, travelling the river in bark canoes. Many trees by the river today still show evidence of bark cut from them in at least the early nineteenth century (HO and DUAP 1996). Other relics of Aboriginal presence are common along the Riverina river systems, including human burial sites, camping sites and middens (NSW NPWS 2001b and Donovan 1997, cited in Eardley 1999).

The extensive use of the Murray by the Bangerang has been compared to the way early settlers used the Hawkesbury in the Sydney Basin Bioregion as a means of communications and trade and as a source of food (HO and DUAP 1996). Near what is now Corowa near Albury there is a line of rocks across the river that the Aboriginal people used to aid the spearing of fish. The Murray supplied the Bangerang with Murray cod and shellfish, while nuts, fruit and tubers were found in the river's surrounds. It is likely that the Bangerang joined the Wiradjuri and Monaro groups at the summer feasts of bogong moths in the alpine country, although they had less of a nomadic lifestyle than these communities (HO and DUAP 1996).

By the 1830s, European settlers had made their presence clear when diseases such as influenza, smallpox and syphilis ravaged the Wiradjuri and Bangerang communities (HO and DUAP 1996). The 1840s saw a worsening of the damage to these communities as they began to let go of their traditional practices that were now made so difficult by European presence. A census of Aborigines in 1845 estimated there were about 2,000 living in the Murrumbidgee Pastoral District, including 100 at Thomas Mitchell's station near what is now Albury, 300 near Deniliquin, and 200 at Urana on the eastern boundary of the Riverina Bioregion. Middens, which reflected the high usage and high population density of the eighteenth century, were deserted, and midden material was used in place of gravel by the Europeans (HO and DUAP 1996). Some traditional life of the Aborigines continued through the 1840s and 1850s but by the 1870s important ceremonies such as corroborees began to attract the interest of settlers who encouraged them as a form of entertainment by paying groups of Bangerang to perform them.

The 1870s also saw social problems arise in Aboriginal communities. Having been forced out of their traditional practices of fishing and being ill treated and unappreciated by the settlers, the men were forced into employment on local stations or went to live in towns such as Albury. The women of the Wiradjuri and Bangerang communities were forced to work as domestic servants and often bore settlers' children (HO and DUAP 1996).

More recently, the reinstatement of marriage practices in the Wiradjuri community has helped them to retain and encourage a sense of identity (HO and DUAP 1996).

8.2 European occupation

John Oxley first explored the Riverina in 1817, following the Lachlan River downstream southwest of Booligal in the centre of the bioregion (Eardley 1999). Oxley was followed almost 20 years later by Thomas Mitchell, who arrived at the junction of the Lachlan and the Murrumbidgee Rivers in 1836, and by Charles Sturt, who explored the Murrumbidgee and lower Murray in the years between 1828 and 1831 (Eardley 1999).

Graziers followed soon after, establishing pastoral runs near Yanco and on the Murrumbidgee and Murray Rivers as far west as Hay between 1835 and 1839 (Eardley 1999). In the 1840s, cattle were the primary industry but by the 1860s sheep were the predominant stock (Eardley 1999).

The river steamer trade was important for the development of Darlington Point (HO and DUAP 1996) from 1858 when the first steamer came past and local entrepreneurs realised the business potential of selling local timber for fuel. Inns opened at Darlington Point in the 1860s and in 1876 McCulloch and Co began trading in a general store and wool-store. The town was successful, continuing in the steamboat trade for a further 50 years.

In 1915 the River Murray Waters Agreement allowed 26 weirs to be constructed with locks, providing permanent riverboat access to Echuca in Victoria. When riverboats were no longer used, the primary focus was on the provision of water for irrigation (Eardley 1999). The Murrumbidgee Irrigation Area was established in the Riverina in 1912, created by the diversion of water from the Murrumbidgee near Narrandera.

Construction of several dams followed in the ensuing years, with the Hume Dam built between 1919 and 1931 on the Murray near Albury, Burrinjuck Dam built on the Murrumbidgee in 1928 and Blowering Dam on the Tumut River built in 1968 (Eardley 1999). Since rice growing is highly dependent on water supply, these dams, along with irrigation schemes endorsed by the state, allowed rice production to grow into an important industry for the region (Eardley 1999). Large-scale rice farming, particularly in the central and south of the bioregion, and the technology used to produce rice, are largely driven by the Japanese export market (Eardley 1999). Water availability in the bioregion due to dams, bore water and increased agricultural technology has allowed the irrigated area to extend its range, enabling the cultivation of irrigated crops in the plains around Darlington Point, Deniliquin and Hay (Eardley 1999).

Cotton crops, which are also highly reliant on water supply, were established in the Riverina Bioregion more recently. Sheep grazing still occurs on land not suitable for cropping, and potatoes are farmed on fast-draining sand hills (Eardley 1999). Orchards and vineyards are also a common land use in the east of the bioregion (HO and DUAP 1996).

The high soil fertility and abundance of water in the Riverina floodplain has made the area highly productive for plant growth. This has influenced land use in the region in the past 150 years, causing extensive changes in the natural distribution and condition of the vegetation cover (Eardley 1999).

The use of the Murrumbidgee River for irrigation and greater crop production has led to Aboriginal poet Iris Clayton lamenting the fate of the Murrumbidgee, especially if it continues to be treated as it has been for the last 200 years:

> *'No one knows how long he's been there*
> *Twisted, old ravaged beyond repair*
> *Father to many, too many to count.*
> *His dying will be a terrible account*
> *Perhaps if the damage is quickly mended*
> *His shores and banks strongly defended*
> *Old River Bidgee need never be*
> *Another lost legend of the Warrajarree.'*
>
> "River Bidgee" by Iris Clayton in *Inside Black Australia: an anthology of Aboriginal Poetry,* Kevin Gilbert (ed) 1988. Penguin, Ringwood, Victoria.

9. Bioregional-scale conservation

The current area of the Riverina Bioregion managed under tenures that achieve some level of conservation is about 124,944 ha or 1.76% of the bioregion, the smallest proportion of all the NSW bioregions.

While the major contributor to conservation in the Riverina Bioregion is land managed under the NPW Act 1974, wildlife refuges currently make the largest contribution in terms of land area managed for conservation.

There is only one national park in the bioregion, Willandra National Park, managed under the provisions of the NPW Act 1974. There are 6 nature reserves (5 of which are wholly contained within the bioregion). Together the national park and nature reserves occupy 23,041 ha or 0.32% of the bioregion. None of the reserves in the bioregion is also managed as wilderness under the Wilderness Act 1987.

Koonadan Historic Site (NPW Act 1974) falls in the bioregion and occupies 21.48 ha or 0.0003% of the bioregion. Of the other tenures provided for under the NPW Act 1974, there are no Aboriginal areas, no state recreation areas and no regional parks in the bioregion.

Some landholders have entered into private land conservation under the provisions of the NPW Act 1974 or NVC Act 1997. These comprise one voluntary conservation agreement (NPW Act 1974) occupying almost 18 ha or 0.0003% of the bioregion, 24 wildlife refuges (this figure is likely to expand to at least 51, once the updated mapping, being undertaken at the time of writing, is complete) on properties occupying 91,254.54 ha or 1.29% of the bioregion, and 24 property agreements (under the NVC Act 1997) which together occupy 2,553 ha or 0.04% of the bioregion. The area of private land conservation totals almost 99,228 ha or 1.40% of the bioregion.

Nine flora reserves (managed under the provisions of the Forestry Act 1916) occupy 2,653 ha or 0.04% of the bioregion and contribute towards biodiversity conservation. SFNSW manages 151,638.75 ha or 2.14% of the bioregion, of which 84,000 ha will be added to the Ramsar convention for the protection of wetlands, more than doubling the area of Ramsar wetlands in NSW.

10. Subregions of the Riverina Bioregion

(Morgan and Terrey 1992)

Subregion -	Geology	Characteristic landforms	Typical soils	Vegetation
Lachlan -	Quaternary alluvial sediments. Clay dominant. Groundwater lakes present. Lower river discharge than other streams.	Complex alluvial fan with numerous distributary channels and floodplains, depression plains, and abandoned lake beds with lunettes. Limited source-bordering dunes.	Red and brown clays, red brown texture contrast soils on levees and terraces, minor deep sands.	Black box and river red gum on channels. Black box, lignum and cane grass in swamps. Saltbush and bluebush with old man saltbush, cottonbush, myall and grasses on the plains. White cypress pine on sandhills.
Murrumbidgee -	Quaternary alluvial sediments. Clay and sand with source bordering dunes and lakes.	Alluvial fan with distributary channels and floodplains, undulating plains with depressions. Source-bordering dunes common.	Red brown earths, grey and brown clays and deep siliceous sands on dunes.	River red gum and river cooba on channels. Black box, lignum and old man saltbush on floodplains. Myall and old man saltbush with other saltbush and grasses formerly widespread on backplains. White cypress pine on dunes.
Murray Fans	Quaternary alluvial sediments. Clay and sand with source bordering dunes, lakes and swamps.	Relatively confined alluvial fan constrained by sediments from northern Victorian rivers, the Murrumbidgee fan and the Cadell fault. Meandering channels, floodplains, source-bordering dunes, overflow lakes and swamps.	Red brown earths, grey clays and deep sands.	Extensive river red gum forests with river cooba on channels and low floodplains. Yellow Box and black box with saltbush on high floodplains and terraces. White cypress pines on dunes, sandy levees and lunettes. Common reed, cumbungi and grasses in swamps.
Robinvale Plains	Quaternary alluvial sediments. Clay dominant. Small overflow lakes.	Narrow floodplain with meandering channels, billabongs, levees and low dunes. Overflow lakes with lunettes.	Red brown earths, grey clays, deep sands and yellow texture contrast soils.	River red gum on channels. Black box, river cooba, oldman saltbush, belah and lignum on floodplains. White cypress pine, mallee acacias and bluebush on lunettes and sand dunes.
Murray Scroll Belt	Quaternary alluvial sediments. Clay dominant, wider plains with larger overflow lakes and salinas. Affected by higher water salinity and summer floods from the Darling River.	Wider floodplain with meandering channels, billabongs, levees and low dunes. Large overflow lakes with large lunettes.	Red brown earths, grey clays, deep sands and yellow texture contrast soils.	River red gum on channels and lake margins. Black box, river cooba, oldman saltbush, belah and lignum on floodplains. White cypress pine, mallee acacias and bluebush on lunettes and sand dunes.

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Riverina Biogeographic Region (IBRA) - Location

Emmdale
Silverton
Broken Hill
Nymagee
Tottenham
Menindee
Ivanhoe
Condobolin
Mossgiel
Lake Cargelligo
Manilla
Hillston
Rankins Springs
Booligal
West Wyalong
Wentworth
Griffith
Temora
Hay
Leeton
Balranald
Coleambally
Narrandera
Lockhart
Wagga Wagga
Jerilderie
Deniliquin
Corowa
Albury
Moama
South Australia
Victoria

Key

- Towns
- Roads
- Rivers
- Waterbodies
- Riverina
- IBRA regions in NSW
- IBRA regions interstate

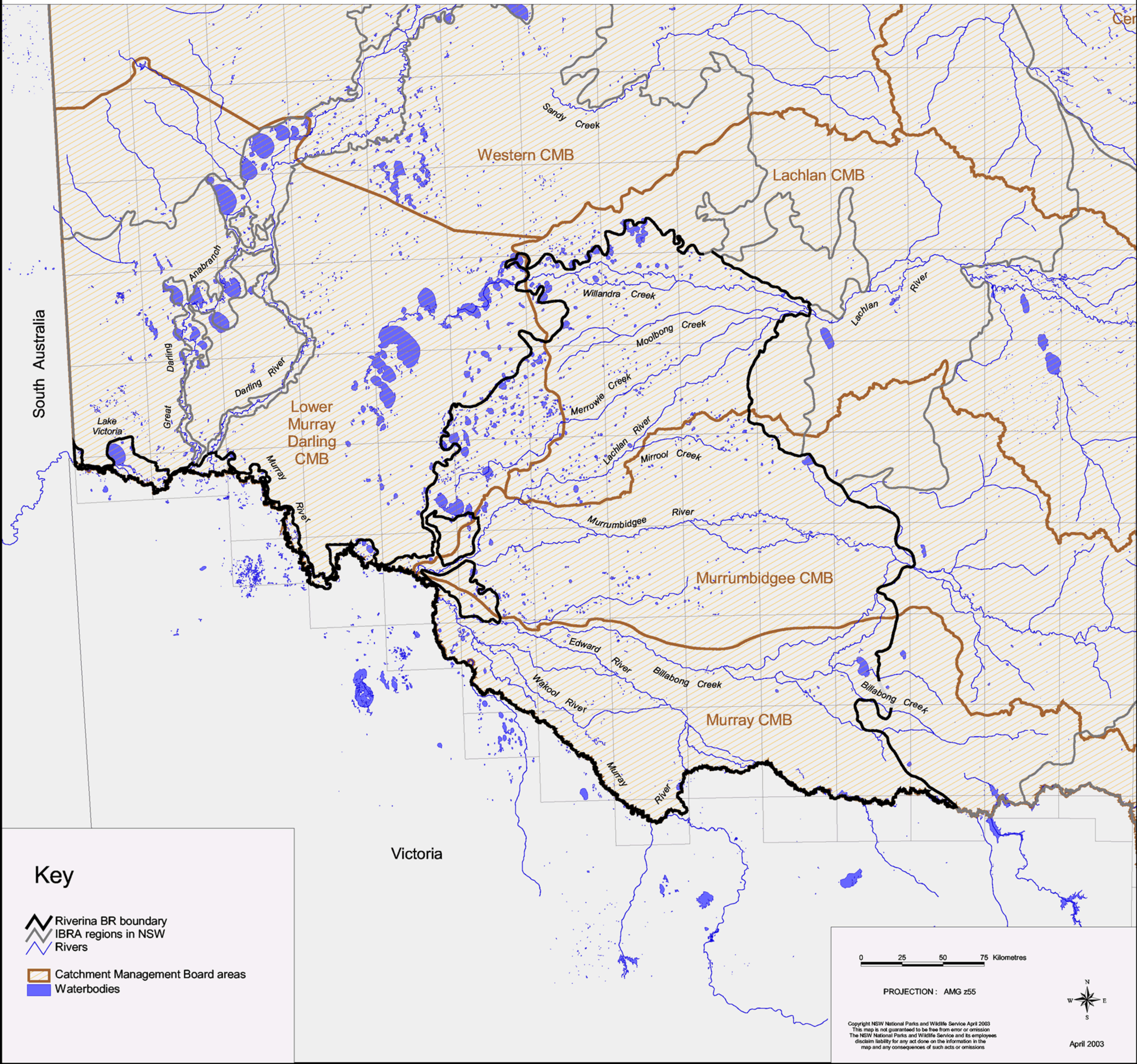
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

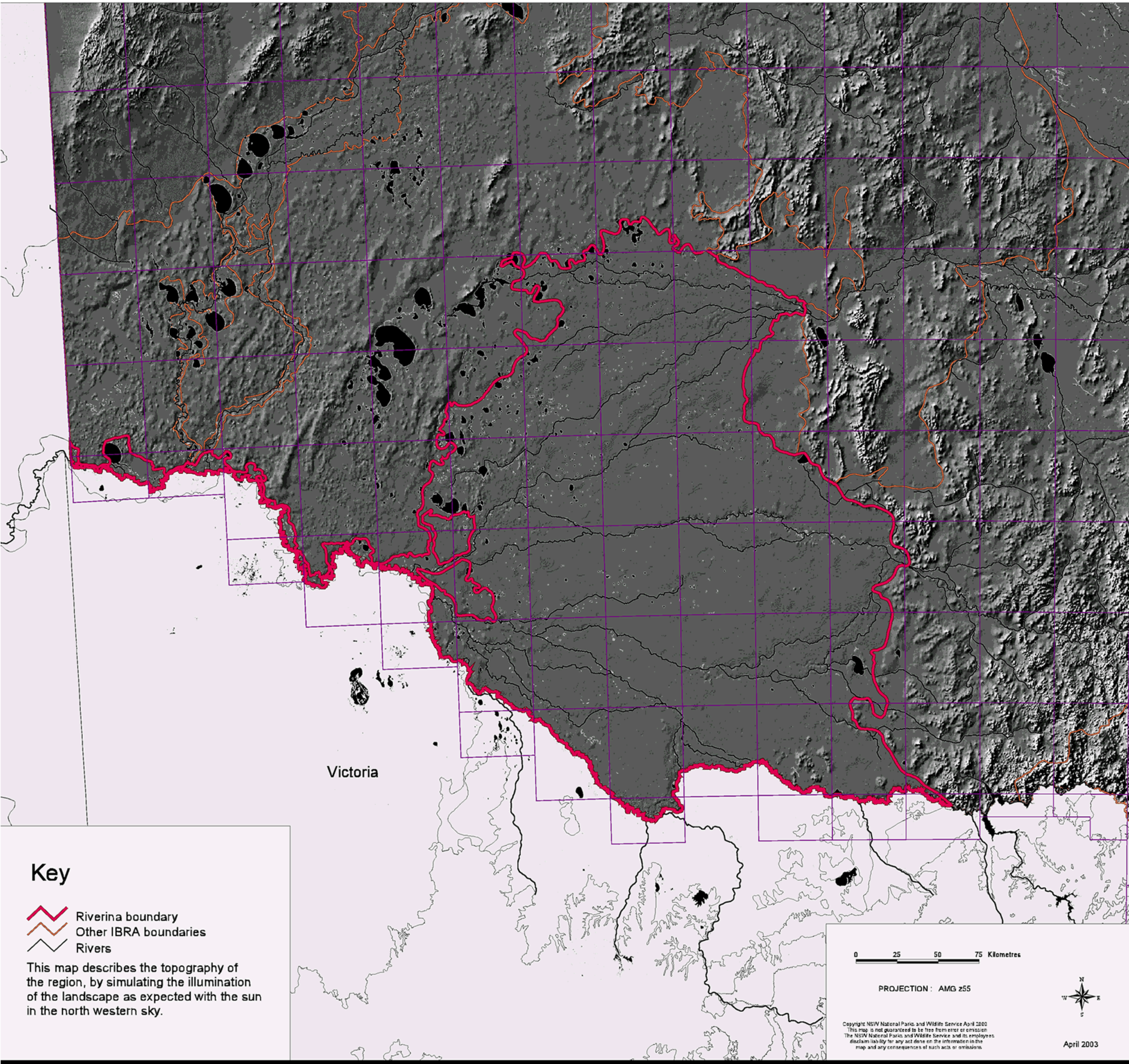
April 2003

Riverina Biogeographic Region (IBRA) - Rivers

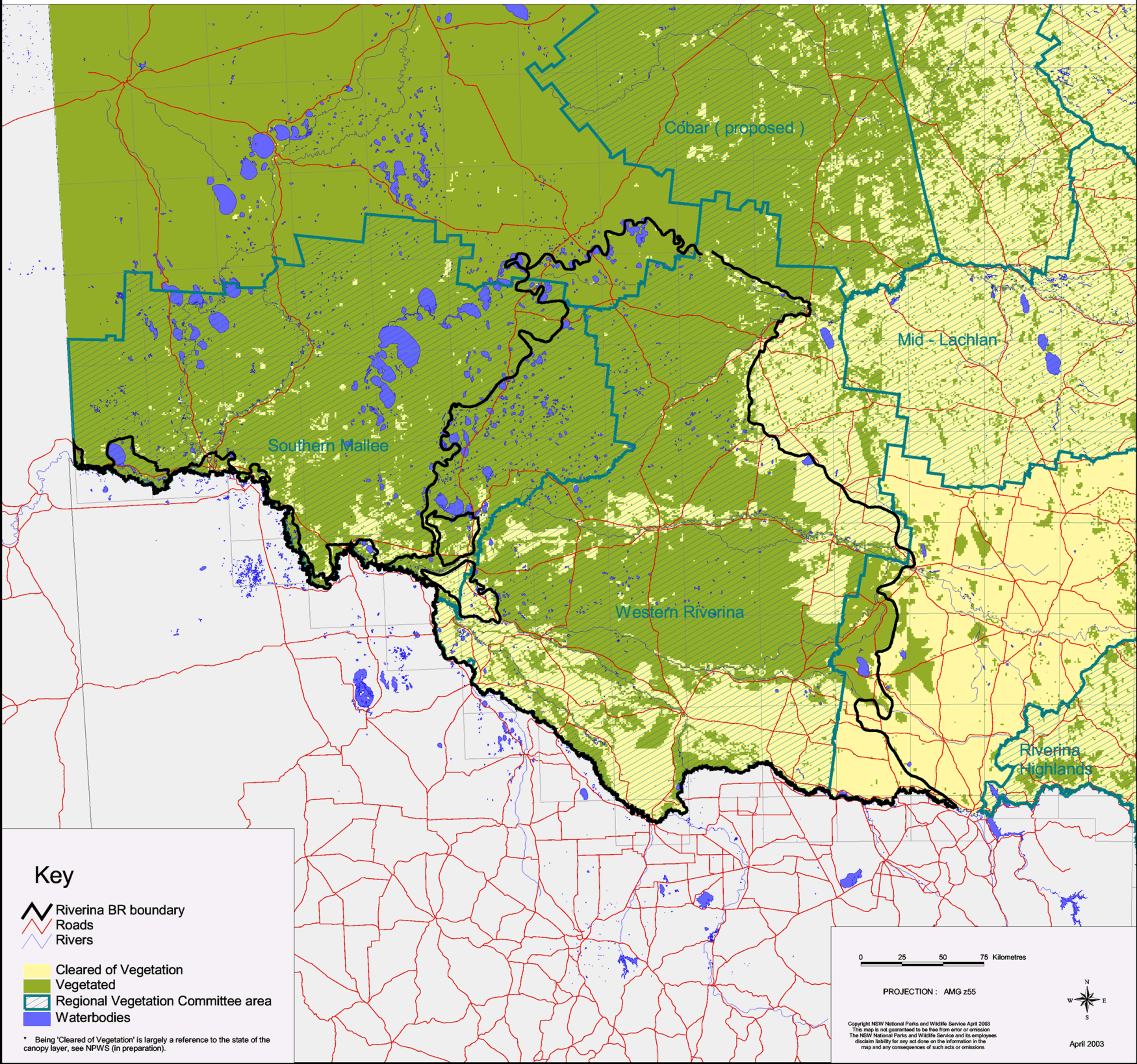


April 2003

Riverina Biogeographic Region (IBRA) - Topography



Riverina Biogeographic Region (IBRA) - Vegetation



Key

- Riverina BR boundary
- Roads
- Rivers

- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Riverina Biogeographic Region (IBRA) - Tenure/Reserves

South Australia

Victoria

Key

- Riverina BR boundary
- IBRA regions in NSW
- Roads
- Rivers

- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

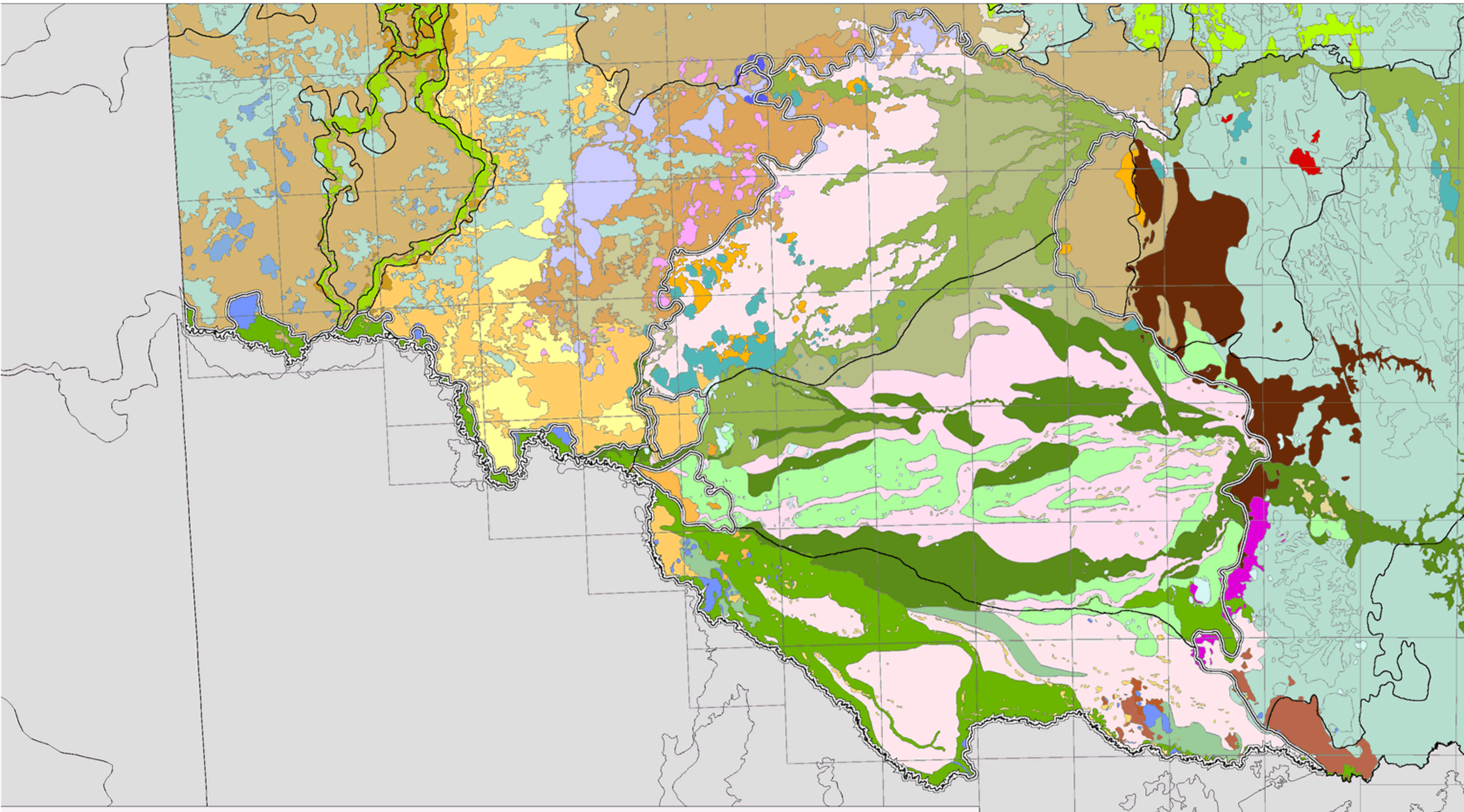
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Riverina Biogeographic Region (IBRA) - Subregions and Landscapes (Mitchell, in preparation)



Key

Subregion boundaries (IBRA)

Riverina (IBRA)

Landscapes of the Riverina

- Albury-Oaklands Hills and Footslop
- Buckingong Gravels
- Cocoparra Basalt Hills
- Cocoparra Ranges and Footslopes
- Ivanhoe-Nangara Linear Dunes
- Ivanhoe-Nangara Sandplains
- Lachlan Channels and Floodplains
- Lachlan Depression Plains
- Lachlan Lakes, Swamps and Lunettes
- Lachlan Sandplains
- Lachlan Scalded Plains
- Lachlan Source-bordering Dunes
- Lower Darling Alluvial Plains
- Lower Darling Channels and Floodplains
- Mallee Cliffs Linear Dunes
- Mallee Cliffs Sandplains
- Mungo Lakes Complex
- Mungo-Marona Lakes and Swamps
- Mungo-Marona Linear Dunes
- Mungo-Marona Relic Lakes
- Mungo-Marona Sandplains
- Murray Channels and Floodplains
- Murray Depression Plains
- Murray Lakes, Swamps and Lunettes
- Murray Sandplains
- Murray Scalded Plains
- Murray Source-bordering Dunes
- Murrumbidgee Channels and Floodplains
- Murrumbidgee Depression Plains
- Murrumbidgee Lakes, Swamps and Lunettes
- Murrumbidgee Sandplains
- Murrumbidgee Scalded Plains
- Murrumbidgee Source-bordering Dunes
- Nymagee Downs
- Oaklands Hills and Footslopes
- Riverina Dunefields
- Riverina Sandplains
- Scotia Groundwater Basins
- Scotia Sandplains

Other Landscapes

IBRA regions interstate

0 25 50 75 Kilometres

PROJECTION : AMG z55

April 2003

CHAPTER 9

The Cobar Peneplain Bioregion

1. Location

The Cobar Peneplain Bioregion lies in central NSW west of the Great Dividing Range. It is one of only two of the state's bioregions to occur entirely within the state, the other being the Sydney Basin Bioregion. The bioregion extends from just south of Bourke to north of Griffith, has a total area of 7,334,664 ha, and occupies 9.2% of the state. The bioregion is bounded to the north and east by the Darling Riverine Plains Bioregion, to the east by the South Western Slopes Bioregion, and by the Riverina and Murray Darling Depression Bioregions to the south and west. The northwestern part of the Cobar Peneplain Bioregion falls in the Western Division.

The Cobar Peneplain Bioregion encompasses the townships of Cobar, Nymagee, Byrock, Girilambone, Lake Cargelligo and Rankins Springs with Louth and Tottenham lying at its boundary.

In the north of the bioregion, Yanda Creek, a major stream, discharges directly into the Darling River which meanders across the bioregional boundary in the northwest. In the east, several small streams flow occasionally into the Bogan River as it crisscrosses the eastern boundary of the bioregion (Morgan and Terrey 1992). The Lachlan River traverses the bioregion in the south with contributions of minor runoff from smaller streams (Morgan and Terrey 1992). The bioregion lies wholly within the Murray-Darling Basin and includes the Barwon, Macquarie, Yanda, Darling, Lachlan and Murrumbidgee catchments.

2. Climate

The Cobar Peneplain is one of 6 bioregions that lie in Australia's hot, persistently dry semi-arid climatic zone. This climate is complemented by patches of sub-humid climate on the southeastern boundary of the bioregion and, in the south, these areas are characterised by virtually no dry season and a hot summer (Stern *et al.* 2000).

Throughout the year, average evaporation exceeds the average rainfall. Rainfall tends to be summer dominant in the north of the bioregion and winter dominant in the south (Creaser and Knight 1996, Smart *et al.* 2000a).

Temperatures are typically mild in winter and hot in summer and exceed 40°C for short periods during December to February (Creaser and Knight 1996). Frosts are frequent in the winter months (Smart *et al.* 2000a) and the lowest daily mean temperature in the bioregion is -6.1°C recorded in Lake Cargelligo in July and August. The hottest period in the bioregion occurs between November and March, with the hottest daily mean temperature in the bioregion being 47.8°C, recorded in Cobar in January.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
15 – 19°C	1.6 – 4.2°C	30.8 – 35.3°C	258 – 537mm	14 – 36mm	30 – 60mm

3. Topography

The Cobar Peneplain Bioregion is a subdued bedrock-controlled landscape in the centre of semi-arid NSW. Described as a low undulating plain, the Cobar Peneplain is easily distinguished from most of the surrounding bioregions which are relatively flatter landscapes of floodplains (Riverina and Darling Riverine Plains bioregions) and sandplains and dunefields (Murray Darling Depression Bioregion). The Cobar Peneplain is a prominent topographical landscape of rolling downs and flat plains punctuated by stony ridges and ranges and is formed on the northwesterly extension of the Lachlan Fold Belt. The more elevated areas of the Cobar Peneplain are characterised by shallow, red soils and aeolian sands associated with the Darling River and the Murray Basin mantle in the lower areas in the west and south, while alluvial deposits from the Bogan River fringe the Peneplain in the east.

4. Geology and geomorphology

The Cobar Peneplain bioregion is based on Palaeozoic rocks largely within the Lachlan Fold Belt. It is lapped by the Murray Basin and the Great Australian Basin and although it is described as a peneplain, the implications attached to this word concerning tectonic stability, landscape and soil genesis should not be uncritically accepted.

The region contains a wide range of bedrock types that exert a strong influence on topography. Rock outcrops form low ranges or lines of residual hills controlled by structure (bedding, folds and faults). Rocks in the eastern half of the bioregion are older (Ordovician), more deformed and more highly mineralised than those in the west (Devonian), although the dominant structural trends in both are northwest. Quartz sandstones, conglomerates and siltstones with low angle folds are typical of the younger rocks, and these form prominent multiple ridges like the ranges at Mt Grenfell up to 300m high, or the more complex folds seen in the Cocoparra Ranges near Griffith. Topography on the older rocks around Cobar is more subdued as residual hills, low rounded ridges, and stony slopes formed on softer, more weathered shales, phyllites and cherts, with only occasional features such as Mt Boppy standing as much as 100 m above the plain.

Igneous rocks are more common in the southern part of the region and granites north of Nymagee make attractive landscapes of rugged peaks and tors. Very small areas of basalt lava are found from Griffith to north of Cobar, with the most interesting being the rare example of 10-16 million year old leucitite lava capping the tabletop peak of El' Capitan.

During the Tertiary and possibly as recently as 5 million years ago, marine sediments were deposited in the Murray Basin with the coastline being the southwestern edge of the Cobar Peneplain. In the Quaternary, after these shallow seas receded, sands were mobilised by wind to form dunes and sandplains that advanced onto the peneplain. A drainage system of wide shallow valleys with a few lakes also developed despite the low rainfall and low gradients. Today the creeks respond to local rainfall but only occasionally deliver water to the Bogan or Darling Rivers.

5. Geodiversity

Significant landscape features include the following:

- the Gunderbooka Range and the Mt Grenfell Ranges are good examples of structural and lithological control of topography. They are also important as sites of cultural and archaeological significance to Aboriginal people;
- Gunderbooka and other peaks stand in isolation on the plains and are likely to have high local endemism in the biota;
- the downs and plains are ecologically distinctive with their apparent uniformity, absence of surface water and well-developed biotic patterning of mulga groves caused by interactions between topography, runoff, soil and vegetation; and
- important mining heritage is present at a number of locations, particularly Cobar, which has been the state's largest copper producer, as well as smaller mines at Nymagee, Mt Hope, Canbelego, Mineral Hill, Tottenham, Ardlethan and elsewhere.

Special geological features include:

- leucitite lavas of El Capitan;
- columnar lavas of the Ambone Volcanics;
- Devonian freshwater fish fossils in the Mt Grenfell area; and
- archaeology and palaeo-environmental potential of Barnato Lakes.

6. Soils

Soils across the bioregion are reasonably uniform and relate closely to topographic position and local geology. On ridge crests they are thin, stony, well-drained red loams. Downslope the soil thickens as a colluvial mantle, usually with a large proportion of stones and with an increasing texture contrast between topsoil and subsoil. On lower slopes the stoniness decreases, red subsoils give way to yellow subsoils, carbonate levels increase and soil drainage is more impeded. Brown clays are more common than grey clays in drainage lines, red sands and earthy sands are widespread but there are only a few areas of sandplain and dunefield.

7. Biodiversity

7.1 Plant communities

The vegetation of the Cobar Peneplain is regionally distinctive. The bioregion is characterised by an undulating to hilly landscape with shallow, red earth soils where the vegetation is mainly open woodlands of bimble or poplar box (*Eucalyptus populnea*), red box (*Eucalyptus intertexta*) and white cypress (*Callitris glaucophylla*).

The more arid areas are dominated by mulga (*Acacia aneura*) (Morgan and Terrey 1992). In the north, mulga and poplar box are dominant. In the southwest, poplar box, red box and white cypress pine become more common, and in the far south, poplar box and white cypress pine dominate. Red ironbark (*Eucalyptus sideroxylon*), hill red gum (*Eucalyptus dealbata*) and grey box (*Eucalyptus microcarpa*) woodlands occur on the eastern edges of the bioregion, extending into the South West Slopes Bioregion. Western vegetation communities dominated by belah (*Casuarina pauper*), wilga (*Geijera parviflora*) and rosewood (*Alectryon oleifolius*) are not well represented. Likewise river red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) are limited as there are few large streams in the region. Grasslands are not common in the bioregion.

Mallee is widespread on rocky ridges and sandplains. Typical species include pointed mallee (*Eucalyptus socialis*), Dwyer's mallee gum (*Eucalyptus dwyeri*), grey mallee (*Eucalyptus morrisii*), green mallee (*Eucalyptus viridis*), mallee broombush (*Melaleuca uncinata*), hill tea-tree (*Leptospermum trivalve*), currawang (*Acacia doratoxylon*), other Acacia sp. and woody shrubs.

Degradation of the Cobar Peneplain Bioregion by heavy grazing has resulted in vast areas being covered by a dense regrowth of woody shrubs (Morgan and Terrey 1992). This shrub layer consists of *Eremophila, Dodonaea* and *Senna* spp. which are unpalatable to stock (Creaser and Knight 1996). The encroachment and proliferation of such species is a major problem

throughout the semi-arid rangelands of NSW (EPA 1997) and hence these species, although native, are known as woody weeds.

Despite the problems of grazing and woody weeds, the dominant woodlands of the bioregion are both structurally and physically intact. In fact, the woodlands of the Cobar Peneplain Bioregion are the most extensive woodland communities to remain in western NSW (Morgan and Terrey 1992).

7.2 Significant flora

Pilaar is the Ngiyampaa name for the belah tree, a significant and special plant to the *Pilaarrkiyalu* or belah tree people of the Cobar Peneplain (Harris *et al.* 2000). *Pilaarr* is a symbol of who the people are and represents their kinship with their *ngurrampaa* or campworld (Harris *et al.* 2000).

Mallee woodland communities (*Eucalyptus spp.*) are widespread throughout the Cobar Peneplain Bioregion, occurring mainly on rocky hills and ridges. Pointed mallee (*Eucalyptus socialis*) communities mainly occupy the sandplain areas while Dwyer's mallee gum (*E. dwyeri*) and grey mallee (*E. morrisii*) occur in shallow soils on crests of ridges in the centre of the bioregion (Cunningham *et al.* 1981). Green mallee (*E. viridis*) communities extend between Griffith and Cobar and further east on low ridges (Cunningham *et al.* 1981). Despite the diversity of mallee species in the bioregion, as much as 90% of the original mallee communities throughout the Cobar Peneplain Bioregion have been cleared, leaving the remnant mallee stands vulnerable to local extinction (Morton *et al.* 1995). Mallee is therefore considered to be of high conservation significance in the bioregion.

The Cobar Peneplain Bioregion supports 19 flora species that are listed in the TSC Act (NSW NPWS 2001). Of these, 9 are listed as vulnerable and 9 as endangered, with one species, *Osteocarpum pentapterum*, presumed extinct in NSW (TSC Act 1995).

Several species found in the Cobar Peneplain Bioregion are listed as vulnerable in the Commonwealth EPBC Act 1999. These include *Bertya "opponens"*, a member of the *Bertya* genus found in mallee communities on shallow soils on ridges in the Cobar-Coolabah area (Bowen and Pressey 1993). The curly-bark wattle (*Acacia curranii*) is also found and occurs only in the Cobar Peneplain Bioregion (NSW NPWS 2001).

The Cobar greenhood orchid *Pterostylis cobarensis* is regionally endemic to the bioregion and is listed as vulnerable in both the TSC and EPBC Acts (Bowen and Pressey 1993, cited in Morton *et al.* 1995). It is under threat by both grazing and noxious weed invasion (NSW NPWS 2001). The winged peppercress (*Lepidum monoplocoides*) is listed in both the TSC and EPBC Acts as endangered and is found mainly in the Cobar Peneplain Bioregion, although some sightings are recorded in the Darling Riverine Plains Bioregion (NSW NPWS 2001). Six species listed as threatened in the EPBC Act are also found in the bioregion.

Other threatened plants include *Lomandra patens, Bothriochloa biloba, Rhodanthe citrina, Monotaxis macrophylla* and *Goodenia occidentalis* as well as *Kunzea* aff. *ambigua, Phebalium obcordatum,* and *Elachoma hornii,* all of which have been described as rare to the region (Morton *et al.* 1995).

7.3 Significant fauna

Fauna surveys undertaken during the Cobar Peneplain bioregional assessment found that the major vegetation types were largely indicative of the fauna found there (NSW NPWS 2000b). For example, vegetation type contributed to fairly accurate predictions of the distribution of bird species and particular bird assemblages (Masters and Foster 2000).

Some fauna species are widespread across the bioregion, occurring across all major vegetation types. For example, reptiles include Carnaby's wall skink

Photo: Murray Ellis

(*Cryptoblepharus carnabyi*) and south-eastern morethia (*Morethia* sp.) which are both fairly widespread west of the Great Dividing Range (Cogger 1992). The bioregion also supports a range of mammals that inhabit much of the Peneplain such as the short-beaked echidna (*Tachyglossus aculeatus*), eastern grey kangaroo (*Macropus giganteus*) and inland mastiff-bat (*Mormopterus* sp.), as well as many woodland birds such as the blue-faced honeyeater (*Entomyzon cyanotis*), rainbow bee-eater (*Merops ornatus*) and mistletoe bird (*Diacaeum hirundinaceum*).

The kultarr (*Antechinomys laniger*) is a dasyurid which is known as the "marsupial mouse" due to its large ears, long tail and irregular hopping gait (NSW NPWS 2000b). The distribution of the kultarr has declined in NSW and the species now occurs in a patchy distribution to the west of the Bogan River, which borders the Cobar Peneplain Bioregion (Dickman *et al.* 1993, cited in Morton *et al.* 1995). Although the species is not directly affected by human activity, the changes in, or intensification of, land use, is thought to threaten its security (Strahan 1983). The kultarr is now listed as endangered in Schedule 1 of the TSC Act 1995.

The now sparse distribution of the greater long-eared bat (*Nyctophilus timoriensis*) and yellow-bellied sheathtail bat (*Saccolaimus flaviventris*) can be mainly attributed to loss of habitat. These bats rely on trees for roosting and the absence of sufficient vegetation has rendered them at risk of predation by cats (Dickman *et al.* 1993, cited in Morton *et al.* 1995). Both species are listed as vulnerable in Schedule 2 of the TSC Act 1995.

The bird species of the bioregion are fairly typical of semi-arid climatic zones, although this bioregion is unusual in that it contains a higher than average proportion of endemic Australian bird species, a reflection of its regionally distinct dry climate. Declines of these species in the small areas of woodland in the bioregion are likely to continue unless adequate representative areas of woodland are protected from clearing and over-grazing.

Despite the scarcity of remnant mallee stands in the bioregion this vegetation supports significant populations of the also vulnerable (TSC Act 1995) striated grasswren (*Amytornis striatus striatus*) (Garnett 1992, cited in Morton *et al.* 1995). The shining bronze-cuckoo (*Chrysococcyx lucidus*) and speckled warbler (*Sericornis sagittatus* or *Chthonicola sagittata*) also rely on these small remnants, and are considered to be in decline in the bioregion (Smith *et al.* 1994, cited in Morton *et al.* 1995).

There are 43 faunal species listed as threatened under Schedules 1 and 2 of the TSC Act 1995 (Smart *et al.* 2000b). Thirty-six of these are listed as vulnerable and 7 are listed as endangered. Although not formally listed in legislation, other fauna species (64 birds, 12 mammals, 23 reptiles and 8 frogs) are identified as being of conservation concern because their numbers are declining or they are locally extinct within the bioregion (NSW NPWS 2000a).

Of the 88 mammal species found in the Western Division at the time of European settlement, 27 were thought to be regionally extinct by the 1990s (Main 2000). In the Cobar Peneplain Bioregion these species include the bilby (*Macrotis lagotis*) and the bridled nail-tail wallaby (*Onychogalea fraenata*), both formerly found in the bioregion and now listed as species presumed extinct in NSW under Schedule 1 Part 4 of the TSC Act 1995.

In addition to the various native animals that typically inhabit the Cobar Peneplain, many feral animals are now commonly seen throughout the bioregion. Of the mammals in the bioregion, domestic livestock, goats, rabbits and foxes were the most conspicuous during surveys (NSW NPWS 2000b). Such species as the fox (*Vulpes vulpes*) are becoming more widespread through western NSW and together with cats (*Felis catus*) prey on the native species of the bioregion (NSW NPWS 2000b).

7.4 Significant wetlands

Lake Brewster is the only wetland of national significance in the bioregion. Considered to be in fair condition, the status of this wetland is declining due to threats by European carp and other feral animals, exotic weeds and altered hydrology. Despite these disturbances, the lake remains an important refuge habitat for water birds as it retains water longer than nearby natural lakes during drought.

Lake Cargelligo is the only bioregionally significant wetland wholly within the Cobar Peneplain. It is described as being in fair condition, affected somewhat by feral animals, exotic weeds, increased water flows and grazing pressure. The site is important for several vulnerable species including brolga (*Grus rubicundus*), freckled duck (*Stictonetta naevosa*), Major Mitchells cockatoo (*Cacatua leadbeateri*), blue-billed duck (*Oxyura australis*), black-breasted buzzard (*Hamirostra melanosternon*) and western blue-tongued lizard (*Tiliqua occipitalis*). The endangered malleefowl (*Leipoa ocellata*) has also been sighted at the lake.

8. Regional history

8.1 Aboriginal occupation

The Cobar Peneplain Bioregion has been managed and occupied by Aboriginal people for at least 40,000-50,000 years (Flannery 1994, Palmer

Photo: Murray Ellis

1994). The bioregion falls within the traditional homelands of several Aboriginal language groups and within these groups are communities living in what they term their "home country". The main language groups are Ngiyampaa in the centre, Ngemba in the north east and Wiradjuri in the south, with the Paakantkji group occupying the area along the northwestern border of the bioregion.

The Ngiyampaa people traditionally occupy the area towards the centre of the bioregion, southwest of Cobar (Smart *et al*. 2000b). To distinguish themselves from other language groups in the area, they refer to themselves as the people who speak Ngiyampaa the Wangaaypuwan (Wongaibon) way, that is, they use the word *wangaay* for "no". Ngiyampaa people also group themselves according to their home country so that the Pilaarrkiyalu (Belah Tree People), Nhiilyikiyalu (Nelia Tree People) and Karulkiyalu (Stone Country People) all occupy different areas of the Ngiyampaa language group within and around the bioregion (Smart *et al*. 2000b). Some Karulkiyalu refer to themselves as Ngemba because their home country to the north of Cobar borders the two language groups. However, these people still speak the Wangaaypuwan way. The Ngemba people in the far north of the bioregion and the Darling Riverine Plains Bioregion use the word *wayil* for "no" and hence refer to themselves as the people who speak Ngemba the Wayilwan way. To the west of this group, also in the north of the bioregion, is the homeland of the Paakantkji or Darling River People who are traditionally linked to the plains of the Darling River from near Bourke south to Wentworth (NSW NPWS 2000c). Paakantji means "belonging to the river" and these people traditionally occupied the Darling River floodplains, spending more time in the Darling Riverine Plains Bioregion (NSW NPWS 2000c). The southern and eastern parts of the bioregion are traditionally occupied by the Lachlan River people known as Kaliyarrkiyalung, who are part of the Wiradjuri language group and use the word *wirraay* for "no" (NPWS 2000c). Wiradjuri is one of the largest language groups in NSW (NSW NPWS 2000c).

The Ngiyampaa (words shown in **bold**), Paakantji (words are underlined) and Ngemba language groups were divided further by a totemic system, where sections of each group comprised individuals linked to an animal or plant totem (Main 2000). The people were traditionally responsible for protecting their totem and would usually refuse to eat the totem that they identified with. Not all totems were food items. Some individuals were responsible for significant stands of vegetation such as grey mallee (**mali**, kaarima, *Eucalyptus morrisii*) which was important for spear timber (Main 2000).

8.2 European occupation

After the first settlement at Port Jackson, western NSW was not explored immediately. This was due to several factors including the need to maintain law and order and the colony's focus being on development in the Sydney area (Austral Archaeology 2000). However, between 1817 and 1846 major exploration of the area west of the Blue Mountains was undertaken by Oxley, Sturt and Mitchell (Whitney 1997) and by 1830 European squatters began to occupy large areas of land in the west (Denny 1994). By 1850 land settlement had occurred through the Cobar Peneplain, as far west as Wilcannia in the Darling Riverine Plains bioregion (Denny 1994).

Newspaper reports in the 1850s printed enticing descriptions of the plains between what are now the townships of Louth and Bourke, encouraging settlers to utilise the productive grazing country of the Cobar Peneplain (Main 2000). Sheep (**thumpa**, *Ovis aries*) and cattle (**kurrukun**, kiyata, *Bos taurus*) were grazed along the Darling River and by the 1860s about half a million sheep and 40,000 cattle occupied its banks. Riverboats on the Darling increased the accessibility of the pastoral country on the Peneplain and wool production in the area was prolific (Main 2000). The first river steamers reached Bourke and Wilcannia in 1859 (Clelland 1984), providing an important transportation link from the wool stations of the Cobar Peneplain.

The settlement of Europeans in the Cobar Peneplain Bioregion and the rest of NSW brought disease and violence to local Aboriginal communities. By 1860 the Aboriginal population of the bioregion had been decimated and this saw an end to many traditional land management practices (Main 2000) that were rapidly replaced by high agricultural production, which had an impact on biodiversity. Prior to settlement of the land by Europeans, forests in the bioregion were open eucalypt and cypress pine woodlands with a grassy understorey (Anon. 1988). The Aboriginal people of the bioregion preserved these open woodlands by regularly burning the vegetation (Anon. 1988), a technique known as "fire-stick farming". When Europeans arrived they reduced burning practices and extended the area in which their stock could graze by ringbarking and clearing the woodlands (Cunningham *et al*. 1981, Anon. 1988). Of 88 mammal species recorded at European settlement, almost 30 were extinct by 1990 (Main 2000). The end of traditional practices such as fire-stick farming led to devastating bushfires in the 1860s and 1870s. The extinction of many medium-sized mammals of the area has been partly attributed to these great fires (Main 2000) as they could not burrow underground like small mammals to avoid the flames. The loss of these species may have also had an impact on the vegetation of the area.

Louth, in the north-west of the bioregion, was established as a 40-acre (about 16 ha) property on the Darling River in 1865 (Clelland 1984). Later it played a key role in the development of mining at Cobar. By 1870 the township of Bourke, just north of the bioregion, was a thriving river port (Clelland 1984). That same year copper was discovered at the Kuburr (Cobar) waterhole and the area was soon established as the Cobar Copper Mine. This was soon followed by the discovery of copper and the establishment in 1871 of two mines – the Cornish, Scottish and Australian (CSA) mine and the United (Occidental) – but these were closed temporarily when they did not achieve immediate financial success. By 1873 Cobar began to establish itself as a permanent township, growing from its former status as a mining outpost (Clelland 1984). Some travellers did not look upon the landscape favourably, an early poem reporting:

> *There's not a mountain, dale, or valley,*
> *No babbling brooks make sudden sally;*
> *Just sand hills fringed with stunted mallee,*
> *That's Cobar.*

In 1877 severe drought conditions took hold of the area, but rainfall improved in the following years (Clelland 1984). Stock numbers declined during this severe drought. Drought followed by several wet years after 1878 allowed many of the cypress pine stands of the area to regenerate unimpeded and a large proportion of these forest stands remained into the 1980s (Anon. 1988). The 1870s also saw the appearance of rabbits which, along with grazing and drought, added to the struggle of the vegetation of the bioregion and much of western NSW (Cunningham *et al*. 1981).

Copper mining commenced in Nymagee in 1878. The commercial mine commenced operation in 1880 (Clelland 1984) as did the local school at Nymagee. Sawmilling in the bioregion began around 1876 when mills were located at Cobar, Canbelego and Coolabah to produce timber for the mining industry and developing towns in the area (Anon. 1988). High demand for firewood for the smelters meant that forests around Cobar were cleared extensively. The mill at Coolabah operated until it burnt down in 1980 (Anon. 1987).

The separation of NSW into Western, Central and Eastern Divisions in 1884 (Whitney 1997) meant that the western proportion of the Cobar Peneplain was held under Western Lands Leases which, due to the restrictions placed on the lands, were used mainly for grazing (Clelland 1984).

The railway reached Bourke in 1885 (Clelland 1984) and was approaching Cobar from Nyngan by the 1890s. The Great Cobar Mine was closed in 1889 due to low yield and heavy rains which made transport difficult and restricted the provision of adequate supplies (Clelland 1984). The mine was later taken over and reopened by the end of the 1890s. Many other mines progressed alongside the Great Cobar, mining copper, gold, silver and lead. In 1889 gold was discovered near Canbelego (between Cobar and Nyngan) and in 1893 there was a rich find at Mt Drysdale (Clelland 1984).

Droughts in the bioregion have occurred in approximate cycles of 20 years' duration over approximately the last 100 years (Anon. 1988). Following the drought of the 1870s, a great drought gripped the Cobar Peneplain between 1895 and 1902 and although rain fell intermittently during this time, overstocking of the land teamed with rabbit and woody weed infestation meant that pastoralists were hit hard financially (Clelland 1984), and lost thousands of sheep.

By the late 1800s violence towards Aboriginal people had abated somewhat and European pastoralists began to cooperate with survivors, allowing them to remain on their traditional lands in exchange for ecological knowledge and technical skills (Main 2000). It has been estimated that by the turn of the century Aboriginal workers undertook 30 per cent of pastoral labour in northwestern NSW (Main 2000).

The main land use in the bioregion is pastoralism (Creaser and Knight 1996), with sheep being the dominant grazing stock while cattle are grazed intermittently according to fluctuations in price and market availability. Land degradation marked by soil erosion and woody weed infestation has occurred in the Cobar Peneplain and this is due largely to overstocking with sheep, cattle and domestic animals (Creaser and Knight 1996) and to feral animals such as rabbits and goats. Subsisting on edible shrubs and trees, goats are farmed in some areas in an attempt to increase incomes from these otherwise unproductive lands (Morgan and Terrey 1992). Cropping occurs opportunistically in the western parts and annually in the southeast.

The bioregion straddles the Western and Central Divisions (Whitney 1997), separating the bioregion into two distinctive landscapes. Cleared freehold land lies to the east of the Western Division boundary (63% of the Central Division component of the Cobar Peneplain is cleared) and to the west lies the vegetated pastoral leases of the Western Division (where less than 21% of this part of the bioregion has been cleared). Widespread clearing and cropping has occurred on the leasehold lands of the Western Division (Nymagee-Rankin Springs province, Morgan and Terrey 1992).

The bioregion encompasses the townships of Cobar, Nymagee, Byrock, Girilambone, Lake Cargelligo and Rankins Springs with Louth and Tottenham at its boundary, while Nyngan, Condobolin and Griffith lie just outside the bioregion. As population records are not kept on the basis of bioregional boundaries, the current population of the Cobar Peneplain Bioregion is difficult to calculate. However, it is likely that the population is in the order of 10,000-15,000 (Dick 2000). Approximately 5,474 people live in the Cobar local government area itself (Australian Bureau of Statistics website – http://www.abs.gov.au) with the majority of the remaining population living on rural properties throughout the bioregion, mainly in the east and south. This is a reflection of the increase in property size from east to west. Most small towns and villages on the Cobar Peneplain are experiencing a decline in population as people, especially the young, move to larger centres outside the region to continue their education or seek employment (Australian Bureau of Statistics 1999, cited in Dick 2000). As the state's largest copper producer and a significant producer of gold, lead, silver and zinc (Creaser and Knight 1996), the bioregion is a lucrative mining region. Together with Broken Hill, Orange and New England, the other 3 major areas in NSW for metallic mineral production, the area around Cobar contributes significantly to the industry value of $1.27 billion (1999-00) (NSW Department of Mineral Resources website – http://www.minerals.nsw.gov.au). There are 7 mines around Cobar: Peak Gold Mine, McKinnons, Girilambone Copper, CSA, Mineral Hill, Tritton and Elura, which principally mine from 3 major mining belts at Cobar, Canbelego and Girilambone. The Cobar belt holds major mineral deposits and its 60 km length passes through the Cobar town area (Creaser and Knight 1996). Together, the 7 mines in the bioregion contain resources of almost 50 million tonnes with a maximum yield of about 8% for the metals mined in the region.

The cessation of operations at the CSA mine in Cobar occurred in early 1998 and soon after recommenced operations in March 1999, but only produced a little over 2,000 tonnes of copper metal in 1998-99 (Department of Mineral Resources website – http://www.minerals.nsw.gov.au). Girilambone Copper Company, just inside the Cobar Peneplain Bioregion, produced copper metal from mining and processing operations near Girilambone in northern New South Wales until mining ceased in early 2000. Concentrates of lead and zinc with silver by-product are produced from mining operations located at Broken Hill and the Elura mines near Cobar. The Elura zinc-lead-silver deposit is the largest mineral deposit yet found in the Cobar Basin (Department of Mineral Resources website – http://www.minerals.nsw.gov.au). The Tritton copper deposit, located 85 km east of Cobar, is the newest project in the bioregion. It is likely that Cobar suffers from fluctuations in population due to mines closing and reopening. Cobar had experienced a local economic boost from mining until the CSA mine closed and over 300 people left the community (NSW NPWS 2000c).

Both the area south of Canbelego and the area around the Lachlan River have several scattered state forests, most of which have been managed for timber production (Morgan and Terrey 1992), mainly for white cypress pine (Anon. 1988).

9. Bioregional-scale conservation

Areas under conservation management in the bioregion occupy 182,623.45 ha or 2.49% of the total. Mechanisms provided for under the NPW Act 1974 are responsible for most of the conserved area. The majority of this is taken up by the 2 national parks and 9 nature reserves which occupy 116,450.90 ha or 1.59% of the bioregion. None of these reserves is also managed as wilderness under the Wilderness Act 1987.

Of the remaining conservation tenures under the NPW Act 1974, there are no Aboriginal areas, no state recreation areas and no regional parks in the bioregion, but there is one historic site of 1,365.09 ha or 0.02% of the bioregion.

No landholders have entered into voluntary conservation agreements under the NPW Act 1974, although landholders on 11 properties have agreed to wildlife refuges and these collectively occupy an area of 60,077.73 ha or 0.82% of the bioregion.

Under the provisions of the Forestry Act 1916 State Forests occupy an area of 81,139.24 ha or 1.11% of the bioregion, and there is one flora reserve which occupies 1,703.70 ha or 0.02% of the bioregion.

There are six property agreements under the NVC Act 1997 with an area of 2,481.55 ha or 0.03% of the bioregion.

10. Subregions of the Cobar Peneplain Bioregion

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Boorindal Plains	Quaternary alluvial blanket over weathered Ordovician and Silurian low grade metamorphosed sedimentary rocks, such as phyllite.	Undulating plains with wide valleys and occasional low stony rises. Gilgai widespread in depressions and swamps.	Red earths and red texture contrast soils with stony lag gravels on slopes. Brown clays and harsh texture contrast soils in depressions and swamps.	Dense mulga, ironwood, poplar box and red box with dense shrubs on ridges and slopes. Dense poplar box with lignum, budda, emu bush, narrow-leaf hop bush and grasses on lower slopes and depressions.
Barnato Downs	Devonian quartzose sandstones in ridges, finer sedimentary rocks under the plains often covered by a mantle of Quaternary alluvium.	Steep ridges and rocky slopes controlled by bedding and joints in bedrock. Relief to 150m, length of ranges up to 40 km. Undulating low ridges and stony rises on softer rocks with a mantle of Quaternary colluvium and alluvium. Sands and minor clay deposits in stream lines. Lakes at Barnato.	Thin, discontinuous stony profiles on ridges, thickening downslope to stony, red, texture contrast soils and red earths on the plains. Valleys generally texture contrast soils with calcium carbonate in subsoil, small areas of cracking brown clays or red sands.	Mulga, red box and grey mallee on crests, white cypress pine and poplar box on slopes. Red box, mulga, white cypress pine and polar box on plains. Areas of belah rosewood and yarran. Pointed mallee in the south. Woody shrubs widespread.
Canbelego Downs	Fine grained Ordovician and Silurian metasedimentary and sedimentary rocks, such as phyllite, slate and chert.	Undulating plateau with low stony ridges and stony rises, relief to 20m. Long low angle slopes and wide (>500m) valleys. Some central sandy channels, a few swamps.	Shallow red loams or stony loams on crests merging to red earths on slopes, plains and through the valley floors. Minor sand deposits along streams, yellow texture contrast soils in swamps.	Mulga with green mallee, red box and numerous woody shrubs on ridges and slopes. Poplar box, white cypress pine, yarran shrubs and grasses in the valleys. River red gum and polar box with sedges, lignum and nardoo in swamps and larger creeks.
Nymagee Downs	Ordovician to Devonian granites, quartzose sandstones, phyllites, slates and acid volcanics. Quaternary aeolian sands and alluvium.	Low hills and ridges with steep slopes. Form controlled by rock type, rounded hills with tors on granite, asymmetric strike ridges in sedimentary rocks. Sandplains from adjacent bioregions lap onto lower slopes.	Gritty red and yellow earthy sands on granite. Stony red earths and texture contrast soils on sedimentary rocks. Calcareous red earths in sandplains, minor earths and grey clays in alluvium.	Dwyer's mallee gum, white cypress pine, kurrajong, golden wattle on granite crests, poplar box and red box on slopes and creeks. White cypress pine, red box, belah with mallee, western wattle grey box and rosewood on crests and slopes of Sedimentary rocks. Mallee communities on sandplains. Dense poplar box and white cypress pine in creek lines.
Lachlan Plains	Devonian quartz sandstone and conglomerate, small areas of granite, and Quaternary colluvial slope mantles and alluvium.	Strike ridges of resistant rocks often following fold patterns. Low rounded hills of granite with sparse outcrop. Wide short valleys connecting to Lachlan floodplains.	Shallow stony or gritty red earths on crests and slopes, thickening downslope as rubbly mantles often with a texture contrast. Deep sandy alluvial soils in valleys with small areas of grey clay in swamps.	Dense currawang, Dwyer's mallee gum and white cypress pine on rocky crests. Same with red ironbark, mallee broombush, hill tea-tree and poplar box on slopes. Poplar box, white cypress pine, mallee, kurrajong, yarran and wilga in valleys. Poplar box and black box in minor swamps.

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Cobar Peneplain Biogeographic Region (IBRA) - Location

Wanaaring
Collarenebri
Brewarrina
Bourke
Walgett
Mount Oxley
Mount Gunderbooka
Louth
Byrock
White Cliffs
Quambone
Coonamble
Mount Drysdale
Girilambone
Mount Grenfell
Cobar
Hermidale
Gulargambone
Wilcannia
Nyngan
Emmdale
Warren
Gilgandra
Nevertire
Nymagee
Dunedoo
Tottenham
Dubbo
Menindee
Wellington
Trundle
Ivanhoe
Condobolin
Parkes
Molong
Mossgiel
Lake Cargelligo
Forbes
Hillston
Canowindra
Rankins Springs
Booligal
Grenfell
Cowra
West Wyalong
Young
Griffith
Boorowa
Temora
Leeton
Hay
Narrandera
Coleambally
Lockhart
Wagga Wagga

Key

- Towns
- Roads
- Rivers
- Waterbodies
- Cobar Peneplain
- IBRA regions in NSW
- IBRA regions interstate

0 25 50 75 Kilometres

PROJECTION : AMG z55

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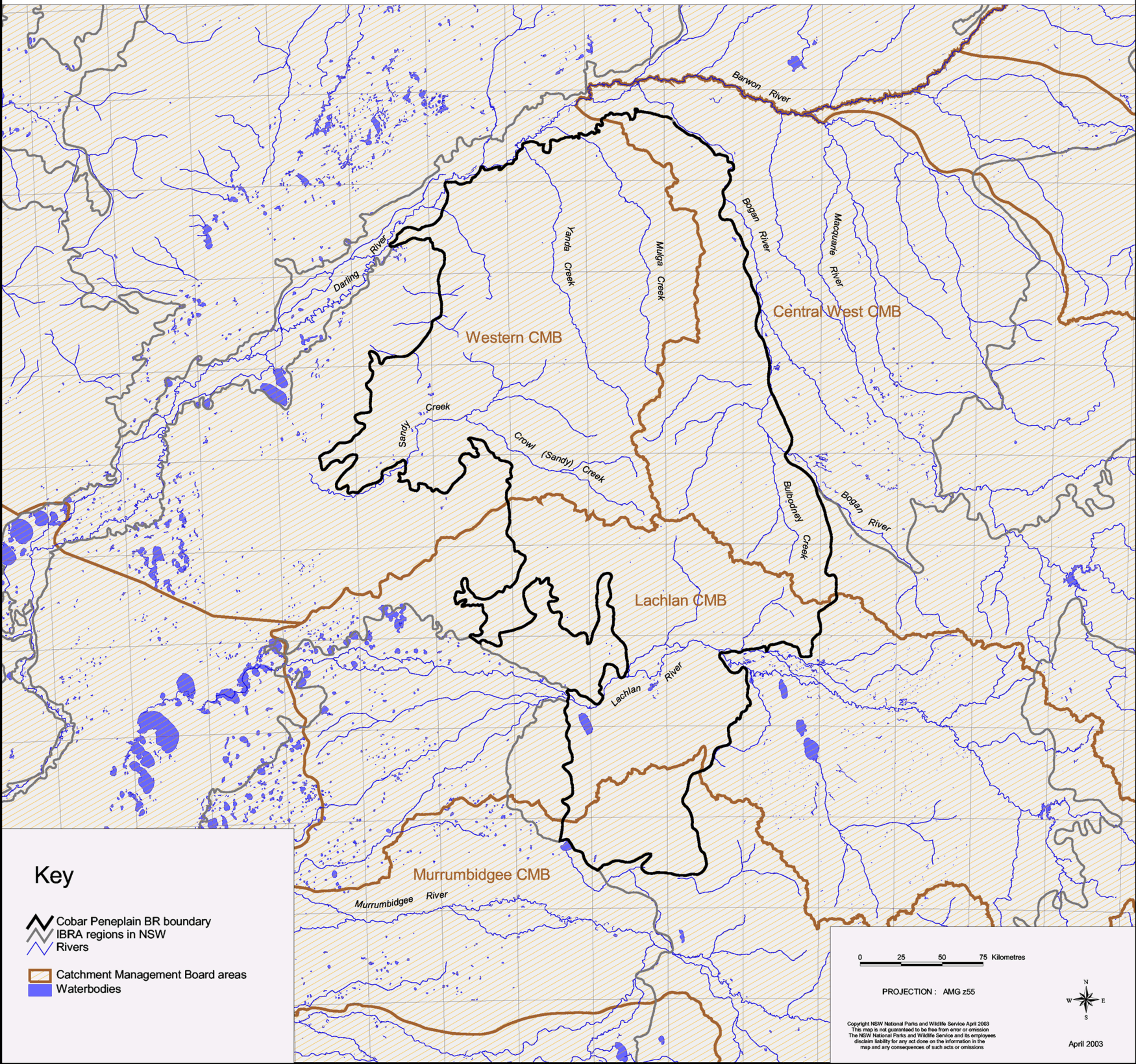
April 2003

Cobar Peneplain Biogeographic Region (IBRA) - Rivers



Key

- Cobar Peneplain BR boundary
- IBRA regions in NSW
- Rivers
- Catchment Management Board areas
- Waterbodies

0 25 50 75 Kilometres

PROJECTION : AMG z55

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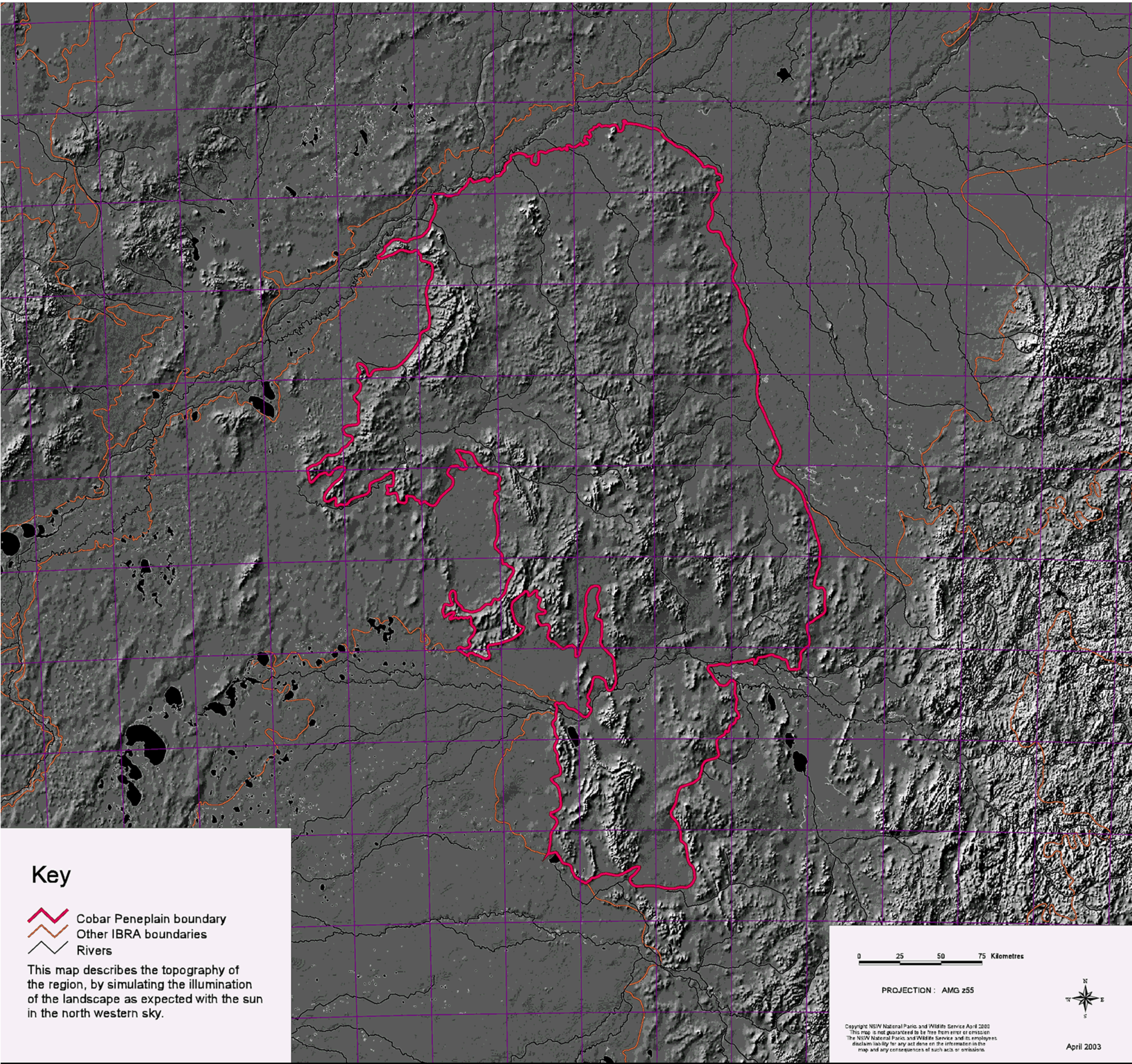
April 2003

Cobar Peneplain Biogeographic Region (IBRA) - Topography



Key

Cobar Peneplain boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

0 25 50 75 Kilometres

PROJECTION : AMG z55

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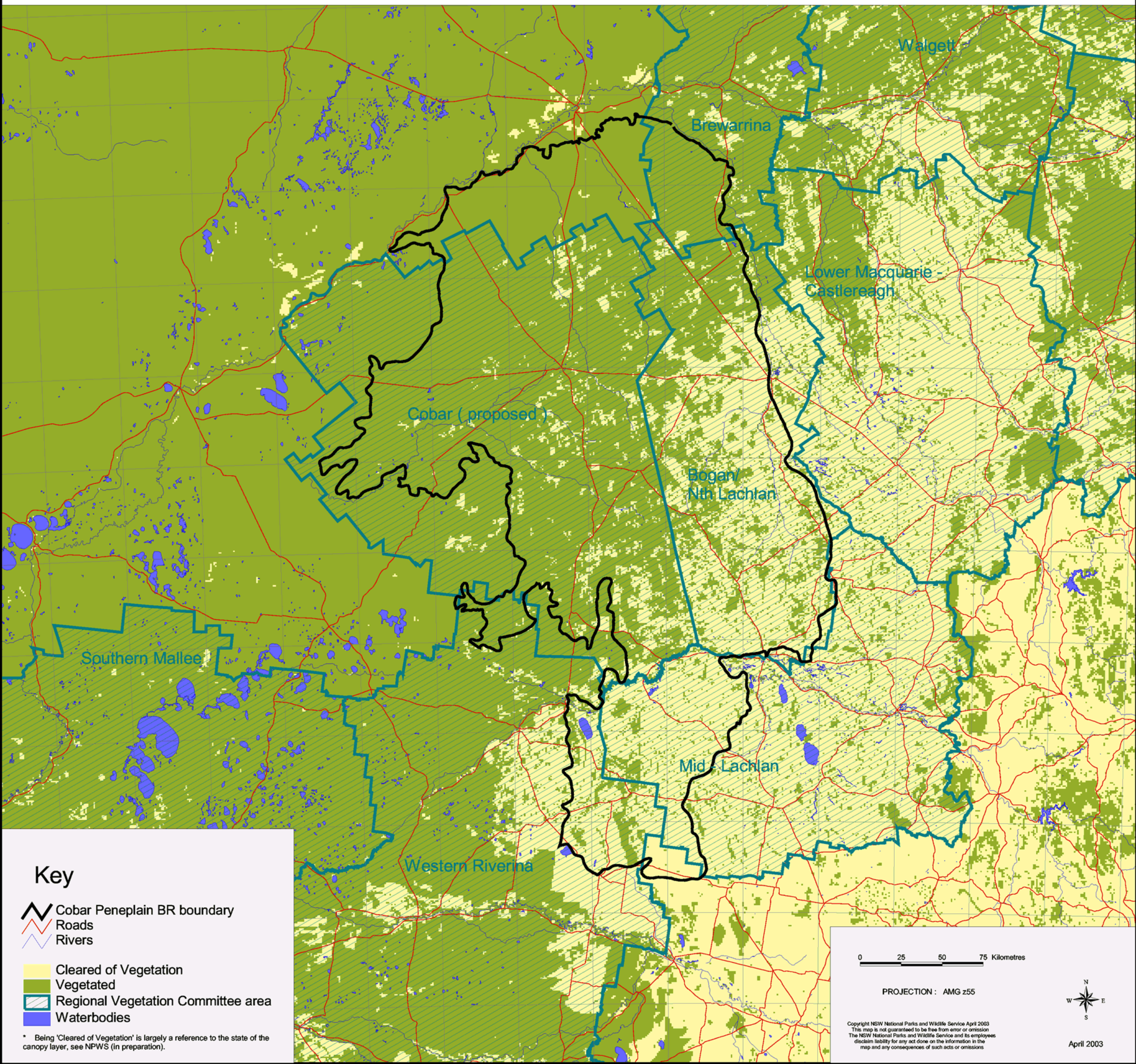
April 2003

Cobar Peneplain Biogeographic Region (IBRA) - Vegetation



Key

- Cobar Peneplain BR boundary
- Roads
- Rivers

- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

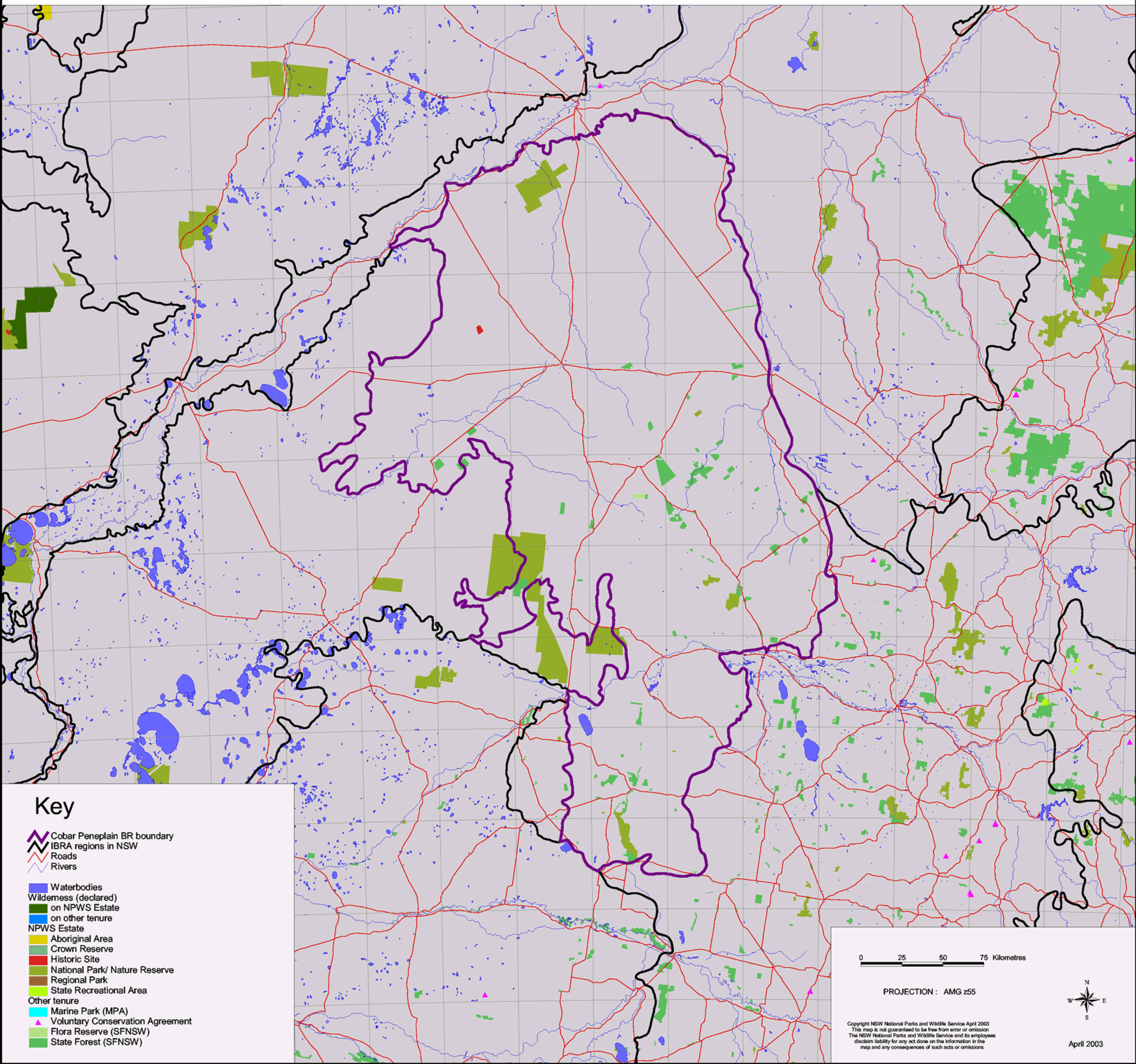
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Cobar Peneplain Biogeographic Region (IBRA) - Tenure/Reserves



Cobar Peneplain Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)

Key

Subregions (IBRA)
Cobar Peneplain

IBRA regions in NSW
IBRA regions interstate

Landscapes

343	489	623
348	490	624
351	492	627
352	493	630
357	500	646
361	501	655
364	502	675
366	503	697
367	504	709
368	506	723
369	517	735
371	527	738
372	537	754
384	544	755
404	550	756
409	551	760
411	575	769
417	576	777
447	577	802
448	579	803
451	581	808
472	586	812
476	603	820
479	604	823
480	612	824
	615	830
	618	831
	622	840

* A description of each landscape, identified by these landscape codes, is available in 'State Conservation Monitoring Project - Monitoring NSW Environments' (NPWS, in preparation)

0 25 50 75 Kilometres

PROJECTION : Lamberts

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April 2003

CHAPTER 10

The South Western Slopes Bioregion

1. Location

The NSW South Western Slopes Bioregion is an extensive area of foothills and isolated ranges comprising the lower inland slopes of the Great Dividing Range extending from north of Cowra through southern NSW into western Victoria with an area of 8,657,426 ha. About 8,070,608 ha or 93.22% of this bioregion occurs in NSW, with the remainder in Vic. (IBRA 5.1). The NSW portion of the bioregion occupies about 10.1% of the state.

The bioregion is bounded by 6 other bioregions: the Riverina and Cobar Peneplain bioregions to the west, Darling Riverine Plains and Brigalow Belt South bioregions to the north, Sydney Basin to the northeast and the South Eastern Highlands Bioregion running along much of the eastern boundary.

The bioregion extends from Albury in the south to Dunedoo in the northeast. Towns located in the bioregion include Wagga Wagga, Mudgee, Cootamundra, Narrandera, Parkes, Gundagai and Young. Griffith lies just outside the western boundary and Crookwell lies just outside the eastern boundary of the bioregion.

The bioregion includes parts of the Murray, Murrumbidgee, Lachlan and Macquarie River catchments.

2. Climate

This bioregion is dominated by a sub-humid climate characterised by hot summers and no dry season. A temperate climate, with warm summers, occurs at higher elevations along the eastern boundary of the bioregion adjacent to the South Eastern Highlands Bioregion. Mean annual temperature increases across the bioregion from low temperatures in the south and east to higher temperatures in the north and west (Gibbons 2001).

Rainfall is distributed across the South Western Slopes Bioregion with high (up to around 1200mm) mean annual rainfall in the east, and lower values (around 400mm) for mean annual rainfall in the west (Gibbons 2001).

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
11 – 17°C	-0.7 – 3.2°C	24.6 – 33.5°C	360 – 1266mm	25 – 64mm	38 – 152mm

3. Topography

The South Western Slopes Bioregion is a large area of foothills and ranges comprising the western fall of the Great Dividing Range to the edge of the Riverina Bioregion. A very wide range of rock types is found across the bioregion, which is also affected by topographic and rainfall gradients that decrease toward the west. These physical differences have an impact on the nature of the soils and vegetation found across the bioregion. Inland streams pass across the slopes in confined valleys with terraces and local areas of sedimentation. Geology, soils and vegetation are complex and diverse but typified by granites and meta-sediments, texture contrast soils and a variety of eucalypt woodlands, making this bioregion the southern equivalent of the Nandewar Bioregion.

4. Geology and geomorphology

The bioregion lies wholly in the eastern part of the Lachlan Fold Belt which consists of a complex series of north to northwesterly trending folded bodies of Cambrian to Early Carboniferous sedimentary and volcanic rocks. Granites are common and mostly located in large scale upfolded bodies of rock. Granite landscapes occur either as central basins surrounded by steep hills formed on contact metamorphic rocks, or as high blocky plateau features with rock outcrops and tors. Hilly landscapes developed on the sedimentary and volcanic rocks are controlled by structural features (bedding and faults) and typically form lines of hills extended along the strike of more resistant rocks such as quartzite. The valleys between ranges are either in granite or generally softer rocks such as shale, phyllite or slate.

Limited areas of Tertiary basalt with underlying river gravels and sands occur, and as the country becomes lower to the west and north, wide valleys filled with Quaternary alluvium and occasional lakes become the dominant landscape form.

At the western edge of the bioregion the alluvial fans of the Riverine Plain have largely buried bedrock forms. Remnants of earlier gravel deposition on these fans, indicative of higher river discharges than today, are found as terrace features in the valleys and as gravel outwash plains.

Some rock types and landscape features deserve special mention. Several limestone outcrops are known, all of which have developed karst topography and carry locally different vegetation. A narrow belt of serpentinite with chemically distinctive soil runs northwest from Tumut to Cootamundra. A very large number of mineral deposits have supported the mining industry over the past 150 years.

5. Geodiversity

Perhaps the greatest significance of this bioregion is the very diversity of its geology, geomorphology and biota. In addition to this there are a number of special features to be noted, as follows:

- several occurrences of limestone with well-developed karst landscape and rich fossil assemblages. Wellington Caves, for example, contains an abundance of extremely important Tertiary and Quaternary vertebrate fossils, the systematic study of which has only just begun despite 170 years of collecting;
- numerous fossil occurrences in other locations;
- the serpentinite belt with its unusual mineralisation, soils and vegetation;
- a very large range of economic mineral occurrences with their attendant mining heritage; and
- numerous sites exhibiting important structural features of folds and faults in the bedrock.

6. Soils

The overall pattern of soils in these landscapes is one where shallow, stony soils are found on the tops of ridges and hills. Moving downslope, texture contrast soils are the norm with subsoils derived from the underlying weathered rock and the topsoils being an homogenised surface mantle of coarser material derived from all parts of the slope. On valley floors subsoils have drabber colours indicative of poor drainage and they may accumulate soluble salts. Dryland salinity is widespread. Alluvial sands and loams are more common than clays in most parts of the landscape but alluvial clays become more important nearer to the Riverine Plain. Over the Quaternary, soils in these landscapes have accumulated a considerable quantity of wind-blown silt and clay from western NSW.

7. Biodiversity

7.1 Plant communities

In the higher rainfall eastern hill country, woodlands and open woodlands of white box (*Eucalyptus albens*) are dominant. To the west and north these give way to vegetation communities dominated by grey box (*Eucalyptus microcarpa*) and white cypress pine (*Callitris glaucophylla*). Other tree species characteristic of the bioregion include red stringybark (*Eucalyptus macrorhynca*) on higher slopes, with black cypress pine (*Callitris endlicheri*), kurrajong (*Brachychiton populneum*), red ironbark (*Eucalyptus sideroxylon*), white gum (*Eucalyptus rossi*), yellow box (E*ucalyptus melliodora*) and Blakely's red gum (*Eucalyptus blakelyi*) occupying the lower slopes. Valley flats are dominated by rough-barked apple (*Angophora floribunda*), with river oak (*Casuarina cunninghammia*) found along eastern streams and river red gum (*Eucalyptus camaldulensis*) lining the larger central and western streams.

Photo: NPWS

In the western half of the bioregion, where altitude and rainfall are lower, Dwyer's mallee gum (*Eucalyptus dwyeri*) dominates areas of granite-derived soils and red ironbark communities occupy areas of sandy soils derived from sedimentary rock. Other common trees include hill red gum (*Eucalyptus dealbata*), white cypress pine and red stringybark in the ranges and grey box woodlands, with yellow box, white cypress pine and belah (*Casuarina pauper*) occupying lower areas. Vegetation communities in the northwest are dominated by poplar box (*Eucalyptus populnea*), kurrajong, wilga (*Geijera parviflora*) and red box (*Eucalyptus intertexta*), and limited areas of bull mallee (*Eucalyptus behriana*), blue mallee (*Eucalyptus polybractea*), green mallee (*Eucalyptus viridis*) and congoo mallee (*Eucalyptus dumosa*) occur in the central west.

Towards the edge of the Riverine Plain, myall (*Acacia pendula*), rosewood (*Heterodendrum oleifolium*) and yarran (*Acacia homalophylla*) associations are found on grey clays. Yellow box, poplar box and belah associations occupy alluvial loams. River red gum grows along all streams, with some black box (*Eucalyptus largiflorens*), lignum (*Muehlenbeckia cunninghamii*) and river cooba (*Acacia stenophylla*) also occurring.

7.2 Significant flora

There are 36 threatened flora species listed in the schedules of the TSC Act in the South Western Slopes Bioregion (NSW NPWS 2001). Of these, 13 are endangered, 22 are listed as vulnerable and one species, *Euphrasia arguta*, is considered extinct in the bioregion.

7.3 Significant fauna

Sixty-seven species listed in the schedules of the TSC Act are found in the South Western Slopes Bioregion (NSW NPWS 2001). Of these, 13 are listed as endangered and 54 are listed as vulnerable.

As the South Western Slopes Bioregion has been intensively cleared and cultivated what remains is mostly fragmented vegetation, a landscape conducive to decline of bird populations. These woodland fragments are important for species such as the vulnerable superb parrot (*Polytelis swainsonii*) and the endangered regent honeyeater (*Xanthomyza phrygia*) as well as non-breeding swift parrots (*Lathamus discolor*). A decline in ground-feeding insectivores was recently observed in the bioregion while numbers of temperate forest birds increased (Australian Terrestrial Biodiversity Assessment 2002). Protection and enhancement of woodland fragments is necessary to prevent continued loss of woodland birds.

7.4 Significant wetlands

Three wetlands are identified as being of bioregional significance. The Barmedman/Yiddah Creek Floodplain is considered to be able to support 32,000 waterbirds (Kingsford *et al.* 1997). The endangered malleefowl (*Leipoa ocellata*), the vulnerable brolga (*Grus rubicundus*) and the painted honeyeater (*Grantiella picta*) have all been recorded in the floodplains (NSW NPWS 2001). The superb parrot has also been sighted. The endangered plant *Austrostipa wakoolica* has been recorded on this floodplain.

Lake Burrendong Reservoir is described as being in good condition and supported over 32,000 waterbirds in 1985, including the Eurasian coot (*Fulica atra*), maned duck (*Chenonetta jubata*) and great cormorant (*Phalacrocorax carbo*). In 1991, the reservoir supported 10,000 waterbirds including grey teal (*Anas gracilis*), Pacific black duck (*Anas superciliosa*) and maned duck (*Chenonetta jubata*). Vulnerable species sighted at the reservoir include the glossy black cockatoo (*Calyptorhynchus lathami*), turquoise parrot (*Neophema pulchella*) and Gilbert's whistler (*Pachycephala inornata*). The endangered swift parrot (*Lathamus discolor*) and regent honeyeater (*Xanthomyza phrygia*) have also been recorded. The Lake also provides habitat for the endangered plant *Swainsona recta* (Australian Terrestrial Biodiversity Assessment 2002).

Wiesners Swamp located in Weisners Swamp Nature Reserve is also bioregionally significant, providing habitat for the vulnerable brolga (*Grus rubicundus*).

The biodiversity of the wetlands of the South Western Slopes Bioregion is affected by a range of threats. These include feral animals, exotic weeds, inappropriate recreational activities, erosion, increased nutrients, sedimentation, altered hydrology, salinity, water extraction and regulation, grazing pressure, pollution from gold mining, lakebed cropping when dry and indiscriminate duck shooting and commercial fishing.

8. Regional history

8.1 Aboriginal occupation

The South Western Slopes was traditionally Wiradjuri country, the largest Aboriginal language group in NSW. The Wiradjuri people travelled to the alpine regions of the South Eastern Highlands and Australian Alps bioregions for the annual summer feasts of bogong moths (HO and DUAP 1996).

Wiradjuri means "people of the three rivers", these rivers being the Macquarie, Lachlan and Murrumbidgee (HO and DUAP 1996). For the Wiradjuri people, the three rivers were their livelihood and supplied a variety of consistent and abundant food provisions including shellfish and fish such as Murray cod (HO and DUAP 1996). In dry seasons the food from the rivers was supplemented with kangaroos and emus hunted for their meat, as well as fresh food gathered from the land between the rivers, including fruit, nuts, yam daisies, wattle seeds and orchid tubers (HO and DUAP 1996).

Evidence of the presence of the Wiradjuri people is common along the Macquarie and Lachlan Rivers in the northern half of the bioregion, but less so along the Murrumbidgee in the south, even though the Wiradjuri people lived on both sides of the Murrumbidgee (HO and DUAP 1996). Surviving carved trees are numerous in the northern part of the traditional Wiradjuri range, whereas there are only 3 of these surviving near the Murrumbidgee (HO and DUAP 1996). The reason for this is not clear, although the original presence of such carved trees is not necessarily indicated by their present-day distribution (HO and DUAP 1996). The Wiradjuri people generally moved around in small groups, using the river flats, open land and waterways with some regularity through the seasons as indicated by debris that has accumulated in these areas (HO and DUAP 1996).

Clashes between the new European settlers and the local Aboriginal people were common around the Murrumbidgee and even further north, particularly between 1839 and 1841. These violent incidents have been termed the "Wiradjuri wars" and involved removal of cattle and spearing of stockmen by the Wiradjuri people in response to killing of their people as well as loss of their fishing grounds and significant sites following invasion by the new settlers (HO and DUAP 1996). Settlers' concerns about the dangers of the Aboriginal people subsided during the 1840s as did the independence of the Wiradjuri people. By the 1850s, although corroborees were still being held on the hills surrounding Mudgee, the culture of the local Aborigines had been vitiated by disease, alcohol and mass European influx during gold rush periods (HO and DUAP 1996).

Despite their tragic recent past, the identity of the Wiradjuri people of the South Western Slopes Bioregion remains robust to the present day, a high degree of marriage within the Wiradjuri community contributing to this

strength of identity. Throughout the bioregion, the major Wiradjuri groups currently live in Condobolin, Peak Hill, Narrandera and Griffith, with significant populations at Wagga Wagga and Leeton and smaller groups at West Wyalong, Parkes, Forbes, Cootamundra and Young (HO and DUAP 1996).

8.2 European occupation

Charles Sturt and George Macleay observed the South Western Slopes Bioregion in 1829 and within 15 years pastoralists occupied most of the river frontages on the Murrumbidgee in the bioregion's south. Further north, John Oxley explored the region in 1817 and, soon after, pastoralists began to bring their cattle to the bioregion. By the 1820s, pastoralists were already making their mark on the landscape. On the southern bank of the Murrumbidgee, Peter Stuckey had introduced what were probably St Helena willows that grew along the river in competition with the native casuarinas and eucalypts (HO and DUAP 1996). Stock were already grazing in the southeast of the bioregion in 1826 and settlement extended west along the Murrumbidgee, with emancipists such as Charles Tompson and George Best settling near what is now Wagga Wagga. As Murrumbidgee frontages were occupied, settlement began to spread to the river tributaries, expanding north and south from the Murrumbidgee. As the traditional lands and lifestyles of the Aboriginal people were overtaken by Europeans, big pastoral properties developed around Mudgee and Rylstone, which became towns in 1837 and 1842 respectively. In the north of the bioregion, a similar pattern developed with the establishment of huge properties initially as cattle stations, with some stations changing to sheep not long after.

Cattle runs were established in Narrandera in 1832 and these were followed from 1840 by sheep stations (NSW NPWS 1991) such as Buckingbong station which was well watered by nearby swamps and creeks even in the drought years (HO and DUAP 1996). Wheat was grown in the area for use on the stations. Albury began as a sheep station in 1835 on both sides of the Murray River and merged soon after with the nearby Wodonga run on what is now the Victorian side of the river (NSW NPWS 1991).

The so-called "Wiradjuri wars" led to the temporary departure of pastoralists from some runs in the area around 1839-40, so fearful were they of resistance by the local Aborigines determined to keep their land. However, most station owners returned later in the 1840s and sheep and cattle numbers grew. A severe drought hit the Murrumbidgee area in 1850-51 just as the gold rushes began and, despite the drought, the people of the bioregion saw success. As the drought yielded and the population of the area increased with the gold rush, meat prices soared and cattle and sheep farmers benefited. Production of beef, which had been increased to cope with demand during the gold rush, slumped in the decades following, while sheep numbers increased five-fold around the Murrumbidgee and Lachlan Rivers up to the 1870s (HO & DUAP 1996). Increased stock numbers led to further occupation of land and to accommodate this ongoing development pastoralists cleared what was left of the uncleared land in the area, sinking wells, building dams and fencing the land as they went.

Gundagai was among the first towns to be settled in the area, developing in the early 1840s around the Gundagai run that was established in 1826. The town fell victim to a devastating flood in 1844 and was shifted to higher ground on the opposite (southern) bank of the Murrumbidgee soon after. By the 1850s Gundagai was the principal town in the south of the bioregion even after destruction from flooding in 1852 and 1853 and again in 1870, the town recovering successfully each time. Eventually Gundagai was overshadowed by Wagga Wagga as the main road south from Dubbo and Forbes to Albury by-passed Gundagai, passing through Wagga instead which had grown considerably, almost doubling in population in the late 1850s. Wagga's importance was also increased by a brief steamboat venture, increasing river traffic through the town in the 1870s.

Nearby Narrandera was gazetted as a town in 1863, growing from its importance as a road traffic centre and a base for a rapidly expanding timber industry, which relied on river transport until the railway took over in 1882. The railway also reached Albury in 1882 (NSW NPWS 1991). German settlers from SA had established vineyards there in the 1850s and other settlers from Vic were attracted to the region for small-scale farming in the 1860s (NSW NPWS 1991). Although gold was discovered at Albury in the 1850s, a major gold rush did not occur until the 1880s. Other towns in the bioregion sprang up away from the major rivers: Junee as a link in the Goulburn to Albury railway, Young and Adelong with gold rushes in the 1850s and 1860s.

Gold was discovered at Adelong in the east of the bioregion in 1852, initiating a township that remained small until 1857. Eighty companies were mining at Adelong between 1857 and 1859 and although Kiandra in the Snowy Mountains caught the focus about this time, a new rush began in Adelong in 1872. Relics of a crushing plant and waterwheels are still evident at Adelong. In the 1900s, shaft mining was replaced by dredging for gold in the alluvial gravel of Adelong Creek, the environmental effects of which are still seen today. Not only did dredging disturb the waterways, the steam dredges required major felling of local box and stringybark timber to use for fuel (HO and DUAP 1996).

Further north, the town of Temora experienced a small gold rush in 1869 and Young, to its east, had a major gold rush before this from September 1860. Temora attracted diggers from Adelong and Kiandra, including many Chinese miners. The area was rich in gold and the mining population mushroomed from 1,500 in October to 3,000 a month later, and by April the following year Temora supported a massive population of 10,000 miners. The Chinese miners were confined to a small area to mine and were the target of brutal rioting later in 1861 (HO and DUAP 1996). As a result, the NSW Chinese Immigration Restriction Act was passed later that year and satisfied miners who had caused the riots against the Chinese moved further north to mine at Forbes in the north of the bioregion. Dredging also began at Temora in 1900 in search of alluvial gold and although it met some success, it was all but finished in 1910. Copper mining, although rare in the bioregion, occurred in the 1870s at Snowball south of Gundagai, but lasted less than a decade before being reopened in 1895 when ore was sent north to Lithgow for treatment (HO and DUAP 1996).

Before the advent of the Murrumbidgee Irrigation Area at the turn of the century, fruit growing, especially cherries, was a successful enterprise around Young in the centre of the bioregion. Although cherries were planted in the region as early as 1847, the first commercial orchards were not a reality until they were planted by Nicole Jasprizza in 1878. Over time, more than 70 cherry orchards were established, and the market was more accessible when the railway reached Young in 1885. By 1933, Nicole Jasprizza was believed to have the largest cherry orchard in the world. Apples, grapes, pears, prunes, quinces, oranges and strawberries were also grown in the area, with Young apples rivalling cherries as the most lucrative crop.

Agriculture in the south of the bioregion made great improvements following the success of an experimental farm established near Wagga in 1892 by the state government. The farm tested strains of wheat and gave advice to farmers while encouraging the planting of new crops including maize, potatoes, grapes and other fruit. A series of dams and other water conservation innovations led to the inception of the Murrumbidgee Irrigation Area in the early 1900s. Soon after, towns such as Griffith on the western border of the bioregion and Leeton in the adjoining Riverina Bioregion were planned by Walter Burley Griffin, the American architect who designed the

nation's capital, Canberra. The town was built in 1916 with the intention that it would service a population of around 30,000, and although the town is growing rapidly even today, it has yet to reach this estimated population. Italian miners arrived in Griffith in 1913 from Broken Hill, providing the area with a multicultural flavour that remains today. After World War I, migration from Italy was rapid and Italian families were able to buy farms cheaply after soldier settlement abated in the 1930s. By 1933, Italians owned about 10% of the local fruit farms and almost 20 years on they owned almost half. In the last 30 years, the area around Griffith has developed a lucrative wine industry (HO and DUAP 1996).

West Wyalong near the centre of the bioregion is a significant location for gold fields (NSW NPWS 1991), with a new project, the Cowal Gold Project, undergoing exploration this year (NSW Department Mineral Resources website – http://www.minerals.nsw.gov.au/). Other basic industries are primary production, consisting of wheat and other cereals, sheep, wool and cattle and also tourism.

9. Bioregional-scale conservation

The South Western Slopes Bioregion contains conservation tenures that together occupy about 184,739.16 ha or 2.28% of the bioregion. Over half of this area is managed as national parks or nature reserves (NPW Act 1974) which cover an area of approximately 97,246.98 ha or 1.2% of the bioregion. Reserves (Crown Land Act 1989) managed by the National Parks and Wildlife Service occupy 1,933.52 ha or 0.02% of the bioregion. Hill End and Yuranighs Aboriginal Grave Historic Sites occupy 0.0003% of the bioregion. However there are no Aboriginal areas, no state recreation areas and no regional parks in the bioregion.

Landholders on 7 properties have entered into voluntary conservation agreements. The area of these properties where conservation management is permanently agreed to occupies about 884.20 ha or 0.0 1% of the bioregion. In addition to this, landholders on 73 properties have agreed to have wildlife refuges over their properties, with the area covered approximately 71,924.67 ha or 0.89% of the bioregion. This figure could expand as mapping is updated. Landholders have also entered into property agreements within the bioregion. One hundred and twenty-seven properties manage 6,960.01 ha in conservation zones (or about 0.09% of the bioregion).

Eight flora reserves (managed under the provisions of the Forestry Act 1916) occupy 4,948.67 ha or 0.06% of the bioregion and contribute particularly towards flora conservation. State forests managed primarily for forestry activities under the Forestry Act 1916 occupy 115,248.11 ha or 1.43% of the bioregion.

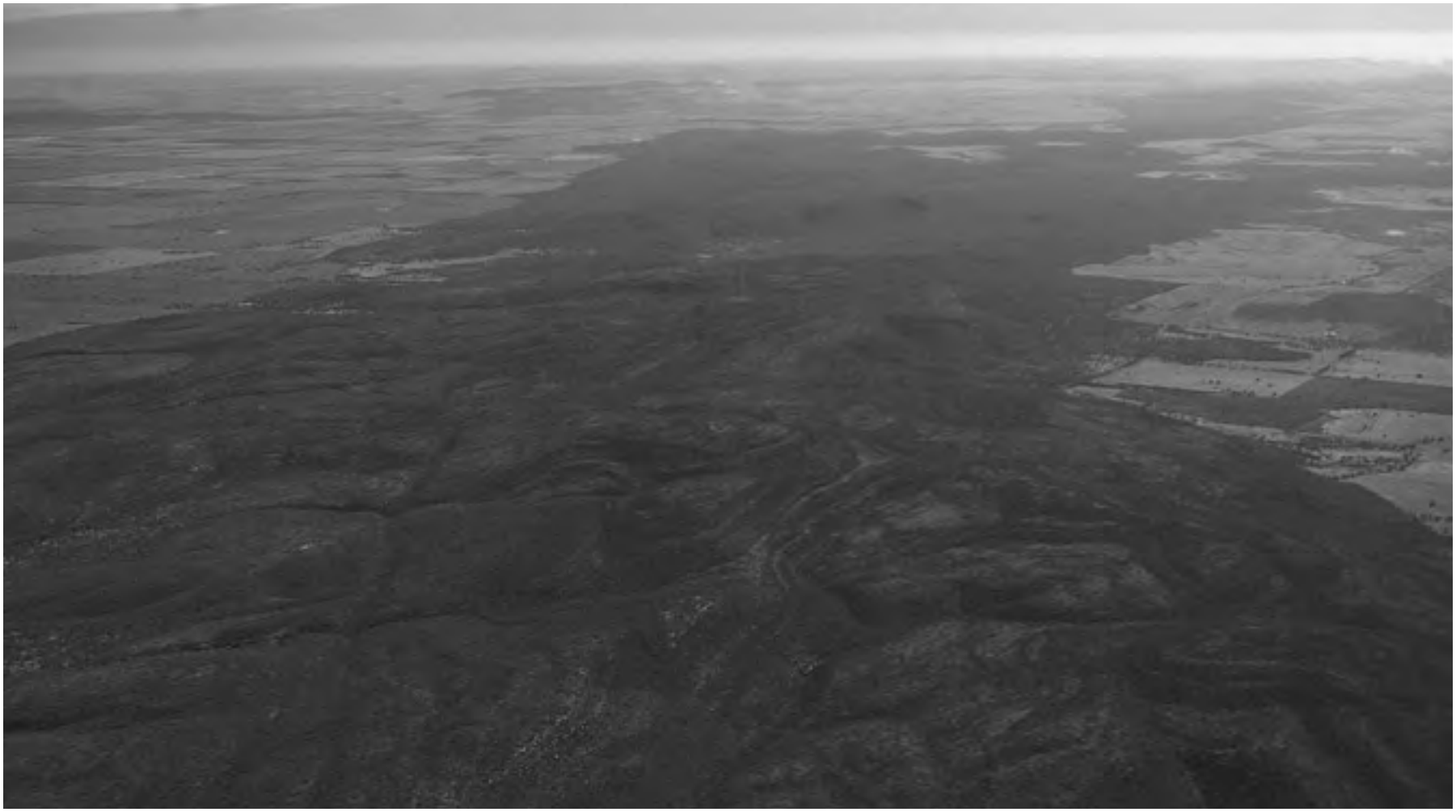

Photo: John Benson

10. Subregions of the South Western Slopes Bioregion

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Upper Slopes -	Ordovician to Devonian folded and faulted sedimentary sequences with inter-bedded volcanic rocks and large areas of intrusive granites.	Steep, hilly and undulating ranges and granite basins. Occasional basalt caps, confined river valleys with terrace remnants.	Shallow stony soils on steep slopes, texture contrast soils grading from red subsoils on upper slopes to yellow subsoils on lower slopes. Alluvial sands, loams and clays.	Open forests and woodlands. Red stringybark on upper slopes with black cypress pine, kurrajong, red ironbark, white gum, white box, yellow box and Blakely's red gum on lower slopes. Merging west to yellow box, grey box and white cypress pine. Rough-barked apple on flats with river oak on upper tributaries and river red gum on lower and larger streams.
Lower Slopes -	As for the Upper Slopes but with larger areas of Tertiary and Quaternary alluvium.	Undulating and hilly ranges and isolated peaks set in wide valleys at the apices of the Riverina alluvial fans.	Similar to the Upper Slopes but with more extensive red-brown earths on undulating plains and more extensive grey clays on alluvium.	Dwyer's gum on granite, red ironbark on sedimentary rocks Hill red gum, white cypress pine and red stringybark in the ranges. Grey box woodlands with yellow box, white cypress pine and belah on lower areas. Poplar box, kurrajong, wilga and red box in the north, limited areas of bull mallee, blue mallee, green mallee and congoo mallee in the central west. Myall, rosewood and yarran on grey clays, yellow box, polar box, and belah on alluvial loams. River red gum on all streams with black box in the west with some lignum and river cooba.

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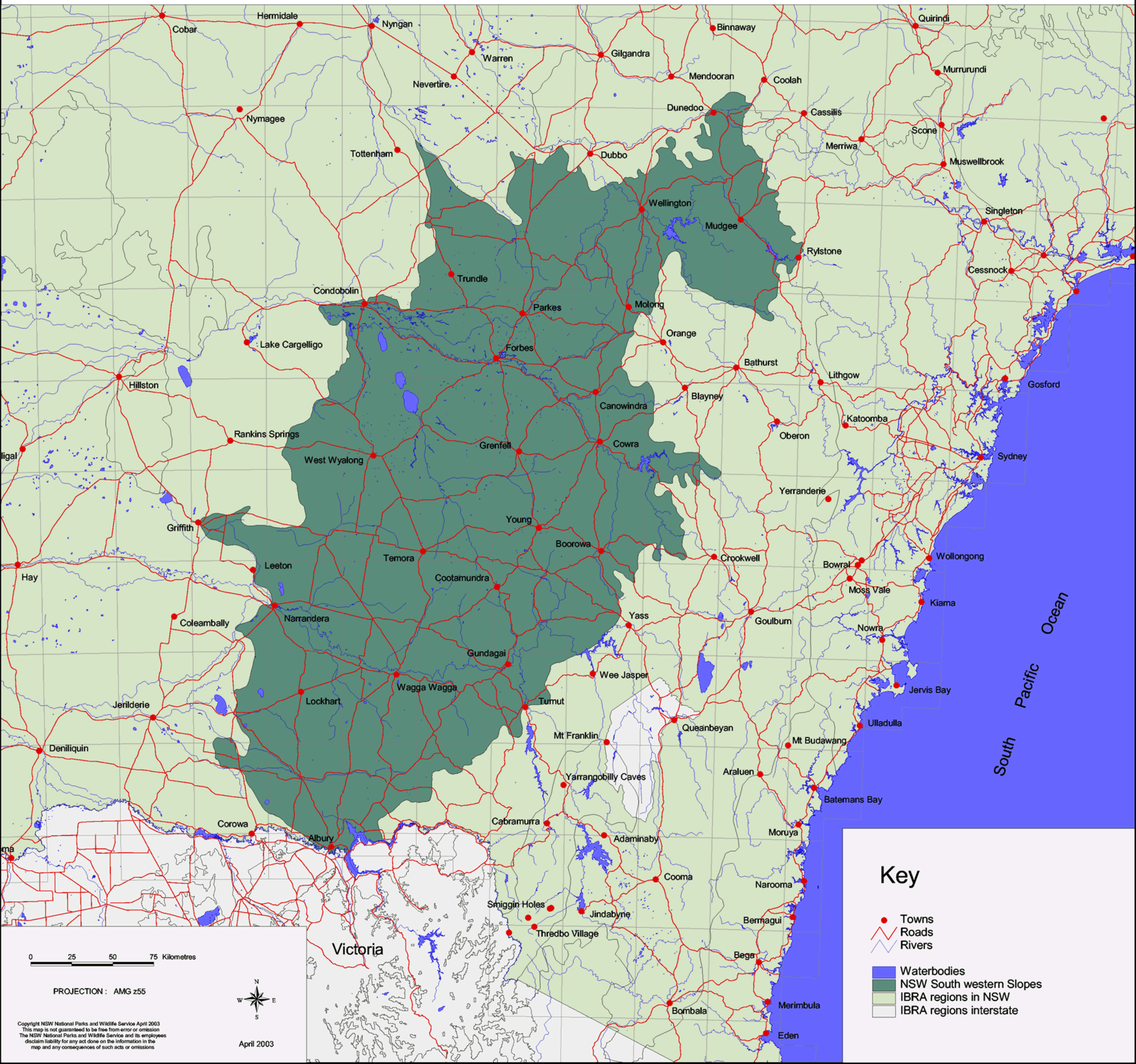
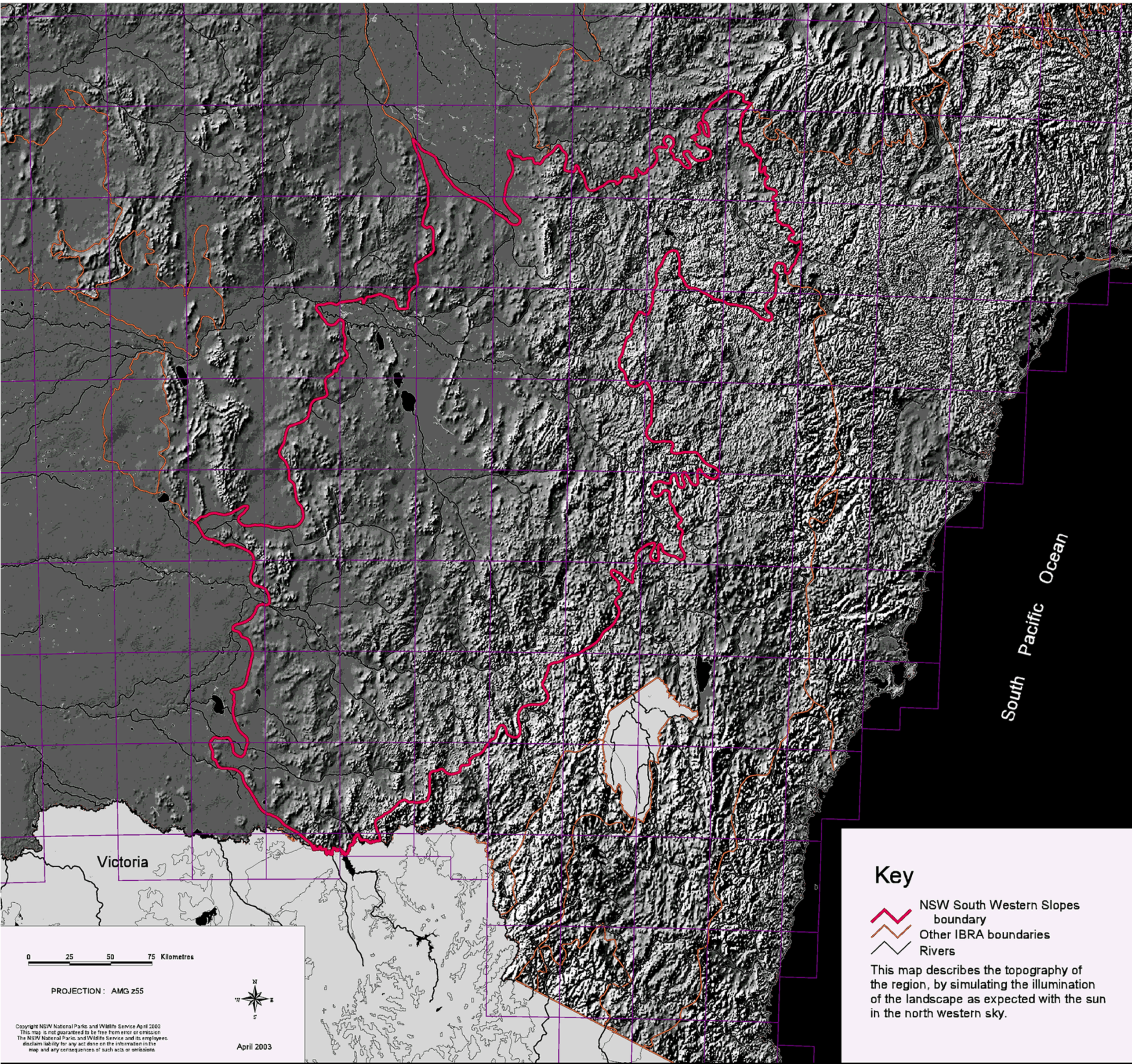
NSW South Western Slopes Biogeographic Region (IBRA) - Location



NSW South Western Slopes Biogeographic Region (IBRA) - Rivers

NSW South Western Slopes Biogeographic Region (IBRA) - Topography



NSW South Western Slopes Biogeographic Region (IBRA) - Vegetation

NSW South Western Slopes Biogeographic Region (IBRA) - Tenure/Reserves

Victoria

South Pacific Ocean

0 25 50 75 Kilometres

PROJECTION : AMG z55

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April 2003

Key

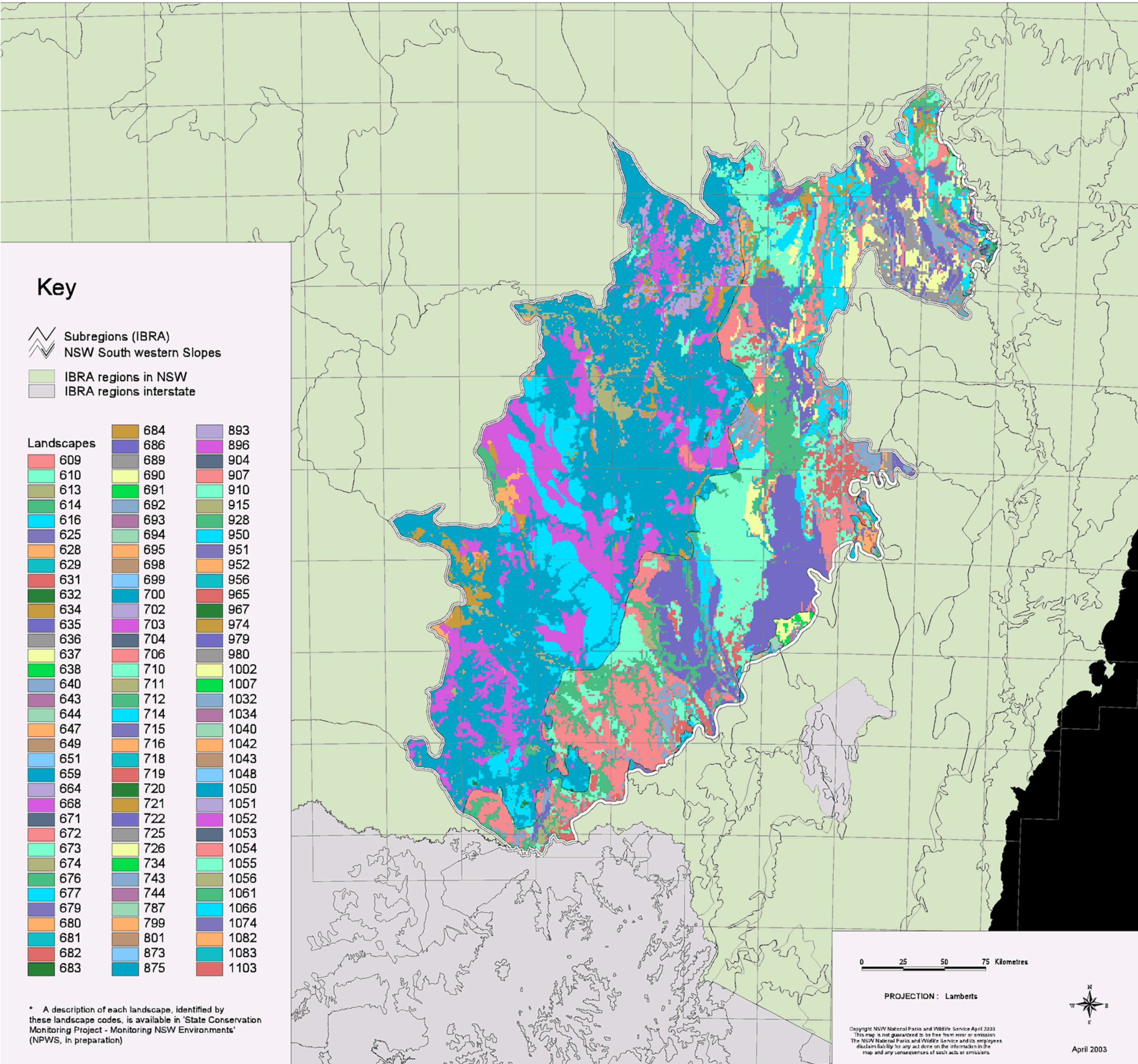
- NSW South western Slopes BR boundary
- IBRA regions in NSW
- Roads
- Rivers
- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

NSW South Western Slopes Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)



* A description of each landscape, identified by these landscape codes, is available in 'State Conservation Monitoring Project - Monitoring NSW Environments' (NPWS, in preparation)

CHAPTER 11

The Brigalow Belt South Bioregion

1. Location

The Brigalow Belt South Bioregion lies in northern NSW and southern Qld, extending from south of Dubbo in central-western NSW to the mid-Qld coast.The bioregion has a total area of 27,196,933 ha, of which 5,333,469 ha (19.61%) fall within NSW (Environment Australia 2000), occupying 6.7% of the state. The bioregion shares its borders with five other bioregions; the Nandewar and North Coast bioregions in the east, the Sydney Basin and South Western Slopes bioregions to the south and the Darling Riverine Plains Bioregion on its western border.

The towns of Baradine, Binnaway, Coonabarabran, Dubbo, Gunnedah, Merriwa, Moree and Narrabri occur within the bioregion.

Several major rivers flow through the bioregion including the MacIntyre, Gwydir, Namoi, Castlereagh, Goulburn, Talbragar and Macquarie Rivers, their catchments forming an integral part of the Murray-Darling River System. The Liverpool Range in the southeastern corner of the bioregion feeds the headwaters of the Hunter and Namoi Rivers.

2. Climate

The bioregion is located within the eastern subhumid region of Australia (NSW NPWS 2000a).

A subhumid climate, with no dry season and a hot summer, characterises the southeastern section of the bioregion, while a generally dry subtropical climate dominates to the northwest. Minor patches to the southeast of the bioregion fall within the temperate zone, with no dry season and a warm summer. To the far west of the bioregion and in the outlier enclosed within the Darling Riverine Plains Bioregion, the climate can be described as hot and semi-arid.

3. Topography

The bioregion forms the southern extremity of the Qld Brigalow Belt but is not dominated by brigalow (*Acacia harpophylla*). It consists of landscapes derived from both extensive basalt flows and quartz sandstones and consequently has very variable soils and vegetation depending on the local rock type or sediment source.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
10 – 19°C	-2.1 – 4°C	22.9 – 34.7°C	449 – 1015mm	23 – 75mm	58 – 120mm

4. Geology and geomorphology

The bioregion's bedrock comprises horizontally bedded Jurassic and Triassic quartz sandstone and shale with limited areas of conglomerate or basalts. Some of the sandstone at the heads of streams forms a low but rugged topography of cliffs and small plateau features. Streams follow the direction of major joint planes in the narrow sandstone gorges, depositing colluvial fans of coarse sands and gravels in the wider valleys. Even further down valley the topography is more subdued, partly buried in alluvial debris and largely eroded to rolling plains. Evidence of larger stream courses of Quaternary age occur in the long, sand-filled channels and clay plains with gilgai, or shallow depressions between ridges in which rainwater collects.

These sedimentary rocks are the fingers' edge of the Surat Basin and the alluvial plains derived from them are important water intake beds for the Great Australian Basin, a large Jurassic-Cretaceous basin covering a large part of eastern Australia, of which the Surat Basin is a part. Some of the Jurassic sediments contain interbedded volcanics that are locally important in affecting soils and vegetation. The more important volcanics are the extensive basalt flows of the Liverpool Range and Warrumbungles (which represents the eroded core of an ancient shield volcano), and flow remnants of the Inverell Basalts at Croppa Creek.

The Liverpool Range is the largest lava field province in NSW, dated between 32 and 40 million years, with up to 400m thickness of basalt covering an area of over 6,000 km2. The lava fields did not have a central volcanic vent but erupted from multiple fissures.

All the volcanic flows covered a pre-existing topography that is now being exposed as a result of erosion, revealing buried river gravels and lake sediments that contain well-preserved plant and fish fossils and a long record of climate change through those slices of geologic time.

Today's landscape is dominated by Quaternary sediments in the form of alluvial fans and outwash slopes that resemble the larger fans of the adjacent Darling Riverine Plains Bioregion to the west but are composed of coarser sediment and fan out at slightly steeper angles. The relative distribution of sediment from basalt or sandstone has a major impact on soil quality and vegetation.

5. Geodiversity

The main features of interest are the landscapes themselves, especially:

- the numerous volcanic attributes of the Warrumbungles; and
- the major lava field of the Liverpool Range with its important grassland ecosystems.

Other features of significance are:

- the diatomite deposits formed in large freshwater lakes during the volcanic times;
- several springs and bogs such as Cuddies Spring, where Pleistocene animal fauna and a pollen record have been recovered in association with early human stone tools;
- excellent Jurassic fish fossils known from a limited outcrop in the Talbragar valley; and
- several important ephemeral wetlands which have a probable record of Quaternary climate change.

6. Soils

Soils vary greatly across this topography, as do microclimate and aspect, so it is necessary to differentiate areas of hill tops and plateau from slopes and valley floors in both sandstone and basalt areas as all of these factors affect the vegetation.

The sandstone ridge tops carry thin, discontinuous soils with stony, sandy profiles and low nutrient status. Downslope, texture contrast soils (soils that have a sharp increase in texture, ie. increase in clay content, on passing from surface soil layers to subsoil) are more common and are typically found with harsh clay sub-soils, while in the valley floors sediments tend to be sorted into deep sands with yellow earthy profiles, harsh grey clays, or more texture contrast soils with a greater concentration of soluble salts.

In basalt country the hill tops have stony, red or brown, well-structured clays with high nutrient values. Similar but often thicker soils are found on the slopes and the valley floors where they too accumulate clay materials.

7. Biodiversity

7.1 Plant communities

The sandstone areas of the bioregion support various forests and woodlands. Woodlands dominated by blue-leaved ironbark (*Eucalyptus fibrosa*), scribbly gum (*Eucalyptus rossii*), black cypress pine (*Callitris endlicheri*), whitewood (*Atalaya hemiglauca*) and rough-barked apple (*Angophora floribunda*) are found on stony sandstone plateau and streams. Silver-leaved ironbark (*Eucalyptus melanophloia*), spotted gum (*Eucalyptus maculata*) and smooth-barked apple (*Angophora costata*) occur on stony hills in the north of the bioregion. Narrow-leaved red ironbark (*Eucalyptus creba*), white cypress pine (*Callitris glaucophylla*), red stringybark (*Eucalyptus macrorhynca*), patches of mallee (*Eucalyptus* sp.) and broom heath (*Melaleuca uncinata*) occur on gentler sandstone slopes.

Pilliga box (*Eucalyptus pilligaensis*), with grey box (*Eucalyptus moluccanna*), poplar box (*Eucalyptus populnea*), fuzzy box (*Eucalyptus conica*), bull oak (*Casuarina luemhannii*), rosewood (*Heterodendrum oleifolium*), whitewood, wilga (*Geijera parviflora*), belah (*Casuarina cristata*), yarran (*Acacia homalophylla*) and budda (*Eremophila mitchellii*) occur on heavier alluvial soils in the west and north of the bioregion. Poplar box, pilliga box, Blakely's red gum (*Eucalyptus blakelyi*), white cypress pine and red ironbark (*Eucalyptus sideroxylon*) occur on coarser soils with occasional silver-leaved ironbark, white box (*Eucalyptus albens*) and fuzzy box in run-on sites. River red gum (*Eucalyptus camaldulensis*) lines all streams.

In the southern end of the bioregion the vegetation comprises narrow-leaved ironbark, white cypress pine and white box on hills and slopes. Patches of black cypress pine, hill red gum (*Eucalyptus dealbata*), the occasional kurrajong (*Brachychiton populneum*) and scrubby acacia species are present in rocky outcrops. Grey box (*Eucalyptus microcarpa*), yellow box (*Eucalyptus melliodora*) and rough-barked apple occur on valley floors, while river red gum lines larger streams and river oak (*Casuarina cunninghamiana*) the tributaries.

The vegetation on the northern basalts includes brigalow, belah, whitewood, wilga, budda and poplar box on the hills, with river red gum, belah, myall (*Acacia pendula*) and poplar box on the flats. White box with silver-leaved ironbark, white wood, bull oak and brigalow are present on alluvial clays. River red gum occurs on all streams.

Diverse grasslands dominate the Liverpool Plains. Common species include plains grass (*Stipa* sp.), panic grass (*Panicum* sp.), windmill grass (*Chloris* sp.) and blue grass (*Dicanthium* sp.) on black earths, with the occasional white box,

yellow box, poplar box and wilga. On the high (colder) ridge crests, silvertop stringybark (*Eucalyptus laevopinea*), manna gum (*Eucalyptus viminalis*) and mountain gum (*Eucalyptus dalrympleana*) are found with snow gum (*Eucalyptus pauciflora*) in cold air drainage hollows. Tallow wood (*Eucalyptus microcorys*), blackbutt (*Eucalyptus pilularis*) and blue gum (*Eucalyptus saligna*) occur on eastern slopes with small areas of vine forest. On northern slopes, white box with rough-barked apple occur with belah in the creeks. Yellow box and Blakely's red gum are found on slopes with a southerly aspect.

7.2 Significant flora

There are 3 endangered ecological communities within the bioregion listed under Schedule 1 of the TSC Act. These are the semi-evergreen vine thicket *Cadellia pentastylis* (poline or scrub myrtle) and carbeen open forest communities. The bioregion is important for the long-term viability of these vegetation communities which are predominantly found here, with a small area lying in the Nandewar Bioregion. The carbeen open forest communities are now restricted to the Brigalow Belt South Bioregion and very limited areas of the Darling Riverine Plains Bioregion.

Benson (1999) notes brigalow, box woodlands and plains grasses as the most threatened plant communities in the bioregion.

The grassy white box woodland community also occurs in this bioregion. It is nationally endangered and protected under the EPBC Act 1999.

At a species level there are 4 endangered and 12 vulnerable species listed in the schedules of the TSC Act. Records within the bioregion tend to be concentrated in the major reserves and forests of the bioregion such as Goonoo State Forest, the Warrumbungles, Mt Kaputar and the Pilliga.

7.3 Significant fauna

Although few systematic surveys have been conducted in the bioregion, records from a variety of surveys can be used to illustrate the vertebrate fauna of the bioregion, which consists of 18 amphibian species, 68 reptiles, 281 birds and 82 mammal species. Many of these species are considered threatened, including the endangered malleefowl (*Leipoa ocellata*), for which the bioregion contains important habitat, and the vulnerable koala (*Phascolarctos cinereus*) which has important populations in the Warrumbungles, the Pilliga and the area around Gunnedah (NSW NPWS 2000a). In this bioregion the tree species often selected by koalas include Blakely's red gum, river red gum and white box, while pilliga box, poplar box, narrow-leaved ironbark and rough-barked apple are occasionally used for food (NSW NPWS 2000a).

Another significant mammal species in the bioregion is the vulnerable eastern pygmy possum (*Cercartetus nanus*) which has a very patchy distribution, with more than 10 records of the species known from each of only 5 locations in NSW, the Pilliga State Forest being one of them (NSW NPWS 2000a).

As its name suggests, the Pilliga mouse (*Pseudomys pilligaensis*) is known only from the Pilliga State Forest, although its preferred habitat has not yet been established. It is thought to prefer mixed eucalypt forest with a shrubby understorey with logs and litter and may face threat from disturbance of ground storey vegetation. (NSW NPWS 2000a).

A species of hopping mouse (*Notomys*) is thought to be present in the remnant forests of the bioregion. It is known only from hairs and footprints and is yet to be found in the Brigalow Belt South.

The birds of the bioregion are highly diverse, mainly consisting of tropical woodland species and comprising the largest number of Australian resident species of any bioregion. There are no major populations of rare or threatened birds in the bioregion and although many birds within the bioregion have restricted ranges, none is endemic. Exotic species are low in numbers and those present are located mainly around towns.

Although bird species diversity is high relative to other NSW bioregions, the Brigalow Belt South Bioregion has experienced major declines in ground-nesting, ground-feeding insectivorous and grassland birds, a trend common to many parts of Australia. An increased reporting rate in the bioregion's rainforest and temperate forest taxa may reflect greater survey effort in these habitats. Reduction of bird diversity in habitat fragments and the continued loss of woodland and freshwater birds seem to be the prediction for the future. However, there was an increase in the numbers of mallard (*Anas platyrhynchos*), cattle egret (*Bubulcus ibis*) and the common myna (*Acridotheres tristis*).

Conservation of habitat is crucial to the survival of small grassland and woodland birds. This should include protecting a substantial and representative proportion of the woodland and grassland landscapes of the bioregion, as well as maintaining and increasing the connectivity between seasonally variable food sources. Ideally, these would be in blocks large enough to discourage invasion by exotic species or fragment specialists such as noisy miners.

7.4 Significant wetlands

Lake Goran is considered to be significant as it provides an important refuge for waterbirds and other species during times of drought (ANCA 1996). When inundated, it is an important waterbird habitat for species such as the red-necked stint (*Calidris ruficollis*), a migratory wader. Despite its significance, the lake's condition is considered to be degraded and tending towards further decline due mainly to salinity, increased flooding and pollution caused by runoff from surrounding agricultural lands.

8. Regional history

8.1 Aboriginal occupation

The Liverpool Plains were the homelands of the Kamilaroi people, a large tribe that supported many sub-groups (HO and DUAP 1996). When Charles Sturt encountered these people on the Macquarie River during his travels, he described them as "clean-limbed and stout, with pleasing faces and intelligent countenances" (HO and DUAP 1996).

8.2 European occupation

The explorer and then Surveyor General of NSW, John Oxley, first visited the bioregion in 1817 and again the following year when he reached the junction of the Macquarie and Talbragar Rivers near the current site of Dubbo. He noted the presence of the local Aboriginal people on the Macquarie River northwest of Dubbo and the suitability of the land for agriculture (NSW NPWS 2000b).

An Agricultural Convict Establishment, settled in the Wellington Valley in 1823 by Governor Brisbane, led to the first European community west of Bathurst and so began the era of pastoral occupation in the bioregion. The Establishment was shut down in 1828, by which time several stations had been set up in the vicinity. In the same year Charles Sturt arrived in the Wellington Valley on his way north. In subsequent years, pastoral occupation around Dubbo quickly escalated as it did throughout the colony (NSW NPWS 2000a).

The official settled area of the colony was divided into 19 counties and the region outside this designated area, including much of the Brigalow Belt South Bioregion, was considered to be "beyond the boundaries" and was thus officially out of bounds for settlement. However, these rules were soon

ignored and pastoralism continued to forge its way through the countryside (NSW NPWS 2000a).

Squatters moved into the bioregion around 1824 but it wasn't until 1836 that squatting licences were issued for grazing (NSW NPWS 2000a). By the early 1830s squatters were establishing runs, including "Dubbo", a run set up by Robert Dulhunty on the Macquarie, along the Talbragar River Valley and on the Macquarie River near Goonoo. By the 1840s pastoralists occupied most of the Macquarie and Talbragar River frontages (NSW NPWS 2000a).

During the early days of European settlement the local Aboriginal people were subjected to violence, disease, sexual exploitation and, as a result of these and other factors such as diminished resources, population decline. One of the notable elements of the interaction between Europeans and Aborigines at this time was the fierce resistance shown by the Aboriginal people (Bickford 1980). Often portrayed as a passive people that let the Europeans simply take their land, the local Aboriginal people were described as "becoming more audacious" in a record of 1842 (HO and DUAP 1996) and some records show a fear of the Aborigines among travelers. Conflict was particularly severe on the Namoi and Gwydir, with conflicting reports suggesting the death of at least 25 Europeans along with much stock and the wounding of many Aborigines and settlers. In 1849 native police were sent to the area and much of the Aboriginal resistance was suppressed by the mid-1850s.

However, despite losing their lands or being forced to share them with the new settlers, the local Aboriginal people of the bioregion resisted covertly, holding onto their traditional practices, including knowledge of languages, stories and sacred sites (Bickford 1980). In some cases, retention of traditional practices was not so covert. Aborigines were known to perform corroborees for audiences of Europeans, performances involving Aboriginal participants from throughout the region. On some occasions, European settlers also observed other traditions such as funerals and burial ceremonies (NSW NPWS 2000b).

The last recorded corroboree was held in 1881, coinciding with the opening of the railway in Dubbo. If such ceremonies occurred after this, they were held in secrecy to avoid intrusion by Europeans or simply to ensure privacy. As settlement by Europeans increased and government control over Aboriginal people strengthened, the importance of continuing traditional practices grew and the need for secrecy became more crucial (NSW NPWS 2000b).

From the 1840s to the 1880s, working relationships between European and Aboriginal people were established in the bioregion, and European station owners allowed the local Aboriginal people to live on their lands in what they termed "station camps". These made workers readily available to landholders while Aboriginal people living on them were able to remain in their country, continuing the cultural and economic practices that had linked them with the land from the beginning. The shortage of European labour during the gold rushes strengthened this system of "dual occupation" and, as a result, the Aboriginal labour force was crucial to the functioning of the pastoral economy between the late 19th and mid-20th centuries. This was particularly due to the willingness of the local Aboriginal people to remain on their homelands and retain the ability to practice spiritual and ceremonial traditions. In 1882 the total Aboriginal population of the area around Dubbo was recorded as being 741 people (NSW NPWS 2000b).

The Liverpool Plains southeast of Narrabri became a site for European settlement in the 1830s and was used mainly for sheep and cattle grazing until the 1880s (Hunt 1980). Wheat farming emerged around Dubbo in the south of the bioregion in the 1860s and by the 1880s cropping was beginning to occur extensively throughout the bioregion, especially on the lighter textured red soils at the footslopes of the Liverpool Ranges (NSW NPWS 2000a). Although there were also droughts at this time the intensification of cropping and demand for land for this purpose led to widescale clearing of forests and other native vegetation (NSW NPWS 2000a).

A transition from pastoralism to agriculturalism based on wheat occurred in the Dubbo area from the 1880s to the 1920s. This was prompted by a major change in land tenure and management. There was a push to "unlock the lands" to allow small selectors access to the vast lands formerly held under pastoral leases. These shifts were aided by legislation changing the nature of land holdings and while these helped unlock the land to small-time farmers, they effectively shut out Aboriginal people from their traditional lands. So began a period of struggle for the Aboriginal community of the Brigalow Belt South Bioregion (NSW NPWS 2000b).

In the 1890s, as agriculture around Dubbo increased, land enclosure continued to decrease property size. The conditions that had allowed dual occupation to occur in the past had now ceased. As a result, Aboriginal communities were driven from their homelands and onto reserves on the outskirts of towns. This served to alienate the Aboriginal community who could now no longer use the land as they had traditionally, due both to their limited access to the land and its changing ecology under agricultural production (NSW NPWS 2000b).

With the loss of their traditional lands, Aboriginal people were even more dependent on European landholders for use of the land than they had previously been on the squatters. They obtained work on the lands, engaged in timber cutting, feral animal shooting, shearing, domestic labour and worked as farm hands and stock hands. In this way they were involved in the local economy while remaining on their lands (NSW NPWS 2000b). Those who were unable to remain on their traditional lands and who lived on reserves or in fringe camps came increasingly under the control of the government which established the Aborigines Protection Board in the 1880s. While the Board was initially responsible only for the distribution of blankets and rations on the reserves, it began to exert a tighter grip on the lives of the Aborigines, placing ever more restrictions on the rights of the communities. Children in Aboriginal communities were increasingly the targets of the Board, which relied on the power vested in it by the Aborigines Protection Act 1909. By 1915, the strength of the Act had increased, giving the Board the power to remove Aboriginal children from their families where the wellbeing of the child was in question.

The reserve closest to Dubbo was the large Talbragar Reserve established in 1898 at the junction of the Macquarie and Talbragar Rivers, where John Oxley arrived in the region only 80 years before in 1818. Other local Aborigines lived in camps along the Macquarie River although the Talbragar Reserve was home to the core of the local community. Aboriginal families often chose to remain in or near reserves to allow their children to gain an education, but in the early to mid-1900s, they found themselves unofficially excluded from local public schools (NSW NPWS 2000b).

During these times, areas such as Goonoo Forest became more important to the Aboriginal community. The forest was dedicated as a formal public "reserve" in 1917, during the period when agricultural production was intensifying in the area. The protection of the forest enabled the Aboriginal people to use it to gather food, both plants and animals, and for social and spiritual purposes without close observation by Europeans (NSW NPWS 2000b).

Areas like Pilliga and Goonoo that were not dedicated in public forests came increasingly under threat from clearing for agriculture and settlement. The passage of the railway line further north and west also contributed to clearing as thousands of trees were felled for use as timber sleepers, further razing the land that had been cleared of timber for housing and fencing since the start of European settlement (NSW NPWS 2000b).

Since European settlement, timber getting has been a regular activity around the Pilliga and Goonoo State Forest areas (NSW NPWS 2000b). Forest management began in the bioregion with forest reserves dedicated in the 1870s. The Forest Conservancy Branch of the Department of Mines placed the

Photo: NPWS

initial Forest Reserves over abandoned Pilliga Crown Land holdings in 1971 (NSW NPWS 2000b), marking the Government's first direct involvement with forest management. Such forest management was driven not by an understanding of ecological process and impacts but by the proposed use of the timber (NSW NPWS 2000b). By the 1870s early landholders and explorers observed changes in the condition of the land and many people were aware of the impacts of agriculture on the landscape even before further damage was caused by drought and rabbits.

The 1950s saw the introduction of technology that allowed cultivation of the heavy-textured soils that had been used for grazing in the past. As a result, cropping on the footslopes of the Liverpool Ranges began to be replaced by grasslands which were used for grazing (NSW NPWS 2000b).

Commercial timber harvesting in the bioregion has concentrated mainly on white cypress (*Callitris glaucophylla*) and narrow-leaved ironbark (*Eucalyptus crebra*) in the last 100 years, although broad-leaved ironbark (*Eucalyptus. fibrosa*), bull oak (*Allocasurina luehmannii*), black cypress (*Callitris endlicheri*) and western box species (*Eucalyptus melliodora, Eucalyptus pilligarensis, Eucalyptus microcarpa* and *Eucalyptus populnea*) have all been harvested in the area in the last 80-100 years (Hartley *et al.* 2000).

Data collected in 1996-97 for the local government areas in the southern two-thirds of the bioregion reported that 34,970 people were employed and earning an average salary of $26,452 each, a figure lower than the NSW average at the time of $30,868 per person (Hartley *et al.* 2000). During this time imports to the region, one-third consisting of household consumables, exceeded exports. Compared to NSW averages, the southern part of the bioregion is much more dependent on agriculture, forestry and fishing while its proportion of mining, utilities and building industries is comparable to the state figures. Although manufacturing and service industries were found to be less than the state figures, the primary industries contribute more than 70% to the exports of the region (cited in Hartley *et al.* 2000).

The main industries, in terms of highest contribution to the economy of the region, are sheep, grains and beef, other agriculture, agricultural services, education, health, public administration, retail trade and wholesale trade.

The period between 1976 and 1991 was a period of high population growth in the region, fuelled by heightened agricultural development including increased irrigation areas. Between 1981 and 1996 the proportion of the employed population of the area was decreasing, apparently as a result of variable international commodity markets and poor seasonal conditions. Excluding Dubbo, the main town centre of the bioregion, the region appears now to be shedding jobs at the same rate as its population decreases, with population losses becoming more common in recent years (Hartley *et al.* 2000).

Early squatters in the Brigalow Belt South Bioregion grazed their cattle in the open woodlands common in the region at the time. After settlers initiated fire control measures, the woodlands were overwhelmed by dense cypress forest growth rendering these areas unsuitable for grazing (Hartley *et al.* 2000) and grazing was shifted to alternative areas. Grazing still occurs in the bioregion, and more recently has been used under grazing permits on State forest estate in the region, to reduce ground fuel, particularly in cypress forests in the Goonoo area, so reducing fire risks.

The mineral industry in the bioregion is based mainly on coal, as the region lies mostly within the Gunnedah Basin, which is a major coal-bearing sedimentary basin. Current mining titles are held for coal and some industrial minerals while exploration titles are held for coal, petroleum, gold, base metals, zeolites and clay minerals (Hartley *et al.* 2000). The majority of coal produced in the region, although comprising a small yield, is for export to overseas markets (Hartley *et al.* 2000).

In terms of tourism in the southern part of the bioregion, the area around Dubbo has both the highest level of visitation and the highest visitor expenditure, making it the major tourist centre of the area (Hartley *et al.* 2000).

9. Bioregional-scale conservation

The majority of the NSW bioregions have less than 20% of their area under conservation-oriented management. The Brigalow Belt South Bioregion is no exception with a total of 155,353 ha or 2.91% of its area held under a relatively limited range of the available conservation mechanisms.

Nineteen national parks and nature reserves are managed under the NPW Act 1974 in the Brigalow Belt South Bioregion, 5 of which are national parks and 14 are nature reserves. These occupy an area of 134,279 hectares or about 2.52% of the bioregion. A portion of these reserves is also protected and managed as wilderness, with just over 1,200 ha of Mt Kaputar National Park comprising parts of the Nandewar and Rusden wilderness areas, occupying about 1,207 ha or 0.02% of the bioregion.

Of the other mechanisms provided for under the NPW Act 1974 there are no historic sites, no Aboriginal areas, no state recreation areas and no regional parks in the bioregion. However, in terms of private land conservation areas, there are 2 voluntary conservation agreements which occupy 128.74 ha or 0.002% of the bioregion. Fifteen wildlife refuges occur on properties occupying about 16,041.85 ha or 0.30% of the bioregion. Six additional properties with wildlife refuges will soon be added to the conservation map.

Twelve property agreements (NVC Act 1997) have been entered into by landholders in the bioregion. The conservation zones of these property agreements occupy about 1,109.74 ha or 0.02% of the bioregion. The total area of private land conservation is thus 1,109.74 ha or 0.02% of the bioregion.

Some 10.60% of the bioregion is managed as State forests for a range of forestry practices under the Forestry Act 1916, including timber production and forest management. Nine flora reserves also occur within the bioregion and occupy 4,091.19 ha or 0.008% of the total area.

About 3,190,400 ha, or a considerable 60.85%, of the bioregion has been cleared.

10. Subregions of the Brigalow Belt South Bioregion

(Morgan and Terrey 1992)

Subregion -	Geology	Characteristic landforms	Typical soils	Vegetation
Inglewood Sandstones	Deeply weathered and lateritised Jurassic-Cretaceous sandstone with associated colluvial lower slopes and alluvial plains.	Undulating low hilly country.	Iron rich uniform profiles on hillcrests merging to harsh texture contrast profiles on lower slopes. Uniform sandy alluvium in stream lines.	Major vegetation types include narrow-leaved ironbark on hillsides, white cypress pine and bull oak on harsh texture contrast soils in gently undulating parts and poplar box on lower slopes and flats. Minor areas of brigalow-belah also occur.
Moonie-Barwon Interfluve One land system only.	Cretaceous sandstones and claystones that are a small part of the Surat Sandstones subregion in Qld.	Low rounded hills, relief to 10m, local dendritic drainage patterns.	Stony red earths often with a gravel pavement. Soils become deeper downslope and accumulate calcium carbonate in drainage lines.	Poplar box, wilga, white cypress pine, budda, warrior bush, ironwood, and belah with mixed grasses underneath.
Northern Basalts	Tertiary basalts over Jurassic quartz sandstones and alluvial sediments derived from these.	Undulating low stony hills, long slopes with sandy wash and heavy clays in the valley floors.	Black loams on basalt ridges, deep sands on sandstone and texture contrast soils on slopes. Heavy grey clay on alluvial flats.	Brigalow, belah, whitewood, wilga, budda and poplar box on basalt hills. Silver-leaved ironbark, spotted gum and smooth-barked apple on stony hills. River red gum, belah myall and poplar box on basalt flats. Silver-leaved ironbark and white cypress pine in sandstone rocks, smooth-barked apple, white cypress, Blakely's red gum, Moreton Bay ash, poplar box, wilga, rough-barked apple, bull oak, on lower sandstone slopes. White box, with silver-leaved ironbark, white wood, bull oak and brigalow on alluvial clays. River red gum on all streams.
Northern Outwash	Tertiary and Quaternary alluvial fans and stream terraces.	Sloping plains with alluvial fans that are coarser and steeper than the Gwydir Fans downstream.	Red loams and heavy brown clays.	Poplar box with white cypress pine, wilga and budda on red soils, belah and brigalow on brown clays.
Pilliga Outwash	Quaternary alluvial fans largely derived from Jurassic quartz sandstone.	Long slopes broken by sandy abandoned stream channels, patches of heavy grey clay and incised stream channels.	Deep texture contrast soils with harsh clay subsoils, grey clay with gilgai.	Poplar box, pilliga box, Blakely's red gum, white cypress pine and mugga on coarser soils. Belah, brigalow, yarran, budda, wilga whitewood, rosewood on heavier soils. River red gum in creek lines, occasional silver-leaved ironbark, white box and fuzzy box in run-on sites.

10. Subregions of the Brigalow Belt South Bioregion *CONTINUED*

Subregion -	Geology	Characteristic landforms	Typical soils	Vegetation
Pilliga	Horizontal Jurassic quartz sandstones, limited shales, Tertiary basalt caps and plugs plus the sediments derived from these rocks.	Stepped sandstone ridges with low cliff faces and high proportion of rock outcrop. Long gentle outwash slopes intersected by sandy stream beds and prior stream channels. A few patches of heavy clay. Includes the spectacular mountain landscape of volcanic domes, plugs and dykes in the Warrumbungles.	Shallow black earths and red loams on basalts. Extensive harsh texture contrast soils, linear patterns of deep yellow sand, stony red brown earths.	White box with white cypress pine and kurrajong on the basalt hills. Blue-leaved ironbark, white gum, black cypress pine, whitewood, and rough-barked apple on stony sandstone plateau and streams. Narrow-leaved ironbark, white cypress pine, red stringy bark, patches of mallee and broom heath on gentler sandstone slopes. Pilliga box with grey box, poplar box, fuzzy box, bull oak, rosewood, wilga and budda on heavier soils in the west and north. River red gum lines all streams.
Liverpool Plains	Quaternary alluvial plains and outwash fans derived from Tertiary basalts. Permian and Triassic quartz sandstones with minor basalt caps.	Undulating hills and sloping plains with alluvial channels and floodplains.	Extensive black earths on low angle slopes. Brown clays, alluvial soils and red or brown texture contrast soils on slopes below sandstone.	Plains grass, panic, windmill grass and blue grass on black earths with occasional white box, yellow box, poplar box and wilga. White box and white cypress pine with rough-barked apple, hill red gum, occasional belah and mulga on texture contrast hillslope soils.
Liverpool Range	Multiple Tertiary basalt flows with intervening sediments and ash fall material, overlying Jurassic quartz sandstones and shale.	Undulating plateau top with steep margins grading to long footslopes.	Stony red brown loams on ridges, shallow stony clay soils on steep slopes grading to deep black earths on lower slopes.	Plateau: open forest of silvertop stringybark, manna gum and mountain gum. Snow gum in cold air drainage hollows. Tallow wood, blackbutt and blue gum on eastern slopes, small areas of vine forest. Slopes: White box with rough-barked apple, belah in the creeks on northern aspects. Yellow box and Blakely's red gum on southern aspect.
Talbragar Valley	Near horizontal Mesozoic quartz sandstone, conglomerates and shales with minor Tertiary basalt caps and extensive alluvial wash plains.	Residual rocky hills, undulating long slopes and wash plains, wide valley floors with sandy streams.	Thin stony loams and texture contrast soils over most of the landscape with deeper sands and brown earths on valley floors.	Narrow-leaved ironbark, white cypress pine, white box on hills and slopes. Patches of black cypress pine, hill red gum, occasional kurrajong and scrubby acacia in rocky outcrops. Grey box, yellow box, rough-barked apple on valley floors. River red gum on larger streams and river oak on tributaries.

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Photo: NPWS

Brigalow Belt South Biogeographic Region (IBRA) - Location

Queensland

Mungindi
Weilmoringle
Lightning Ridge
Collarenebri
Moree
Wanalda
Tenterfield
Inverell
Glen Innes
Bingara
Grafton
Brewarrina
Walgett
Wee Waa
Mount Kaputar
Narrabri
Woolgoolga
Guyra
Coffs Harbour
Armidale
Ebor
Bellingen
Quambone
Coonamble
Baradine
Gunnedah
Walcha
Tamworth
Girilambone
Gulargambone
Coonabarabran
Hermidale
Binnaway
Quirindi
Wauchope
Nyngan
Gilgandra
Warren
Murrurundi
Nevertire
Mendooran
Coolah
Tarea
Barrington
Dunedoo
Cassilis
Scone
Merriwa
Tottenham
Dubbo
Forster
Muswellbrook
Wellington
Singleton
Mudgee
Maitland
Rylstone
Newcastle
Molong
Parkes
Orange
Forbes
Bathurst
Lithgow
Gosford
Blayney
Canowindra
Katoomba
Oberon
Cowra
Sydney

South Pacific Ocean

Key

- Towns
- Roads
- Rivers
- Waterbodies
- Brigalow Belt South
- IBRA regions in NSW
- IBRA regions interstate

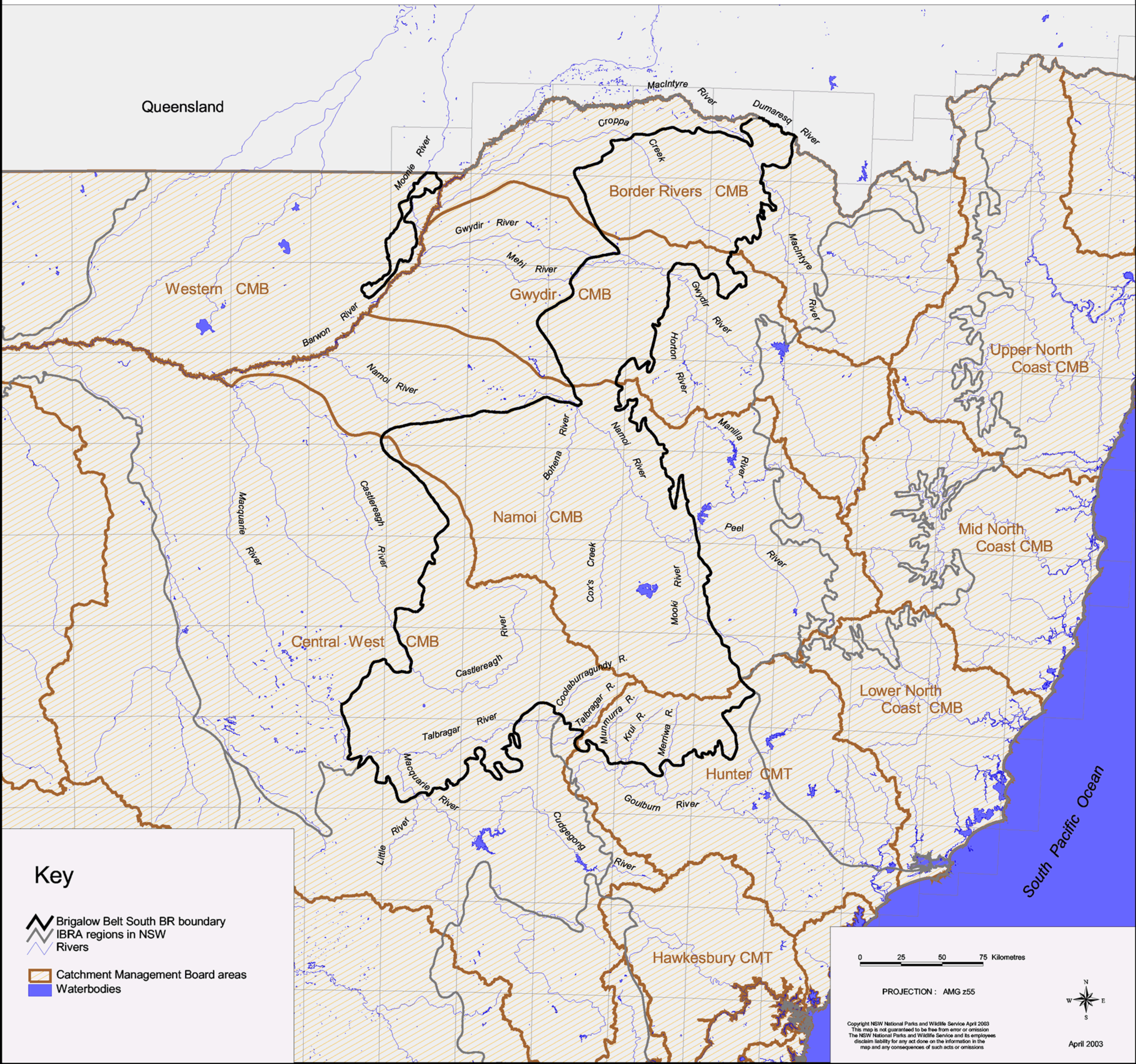
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

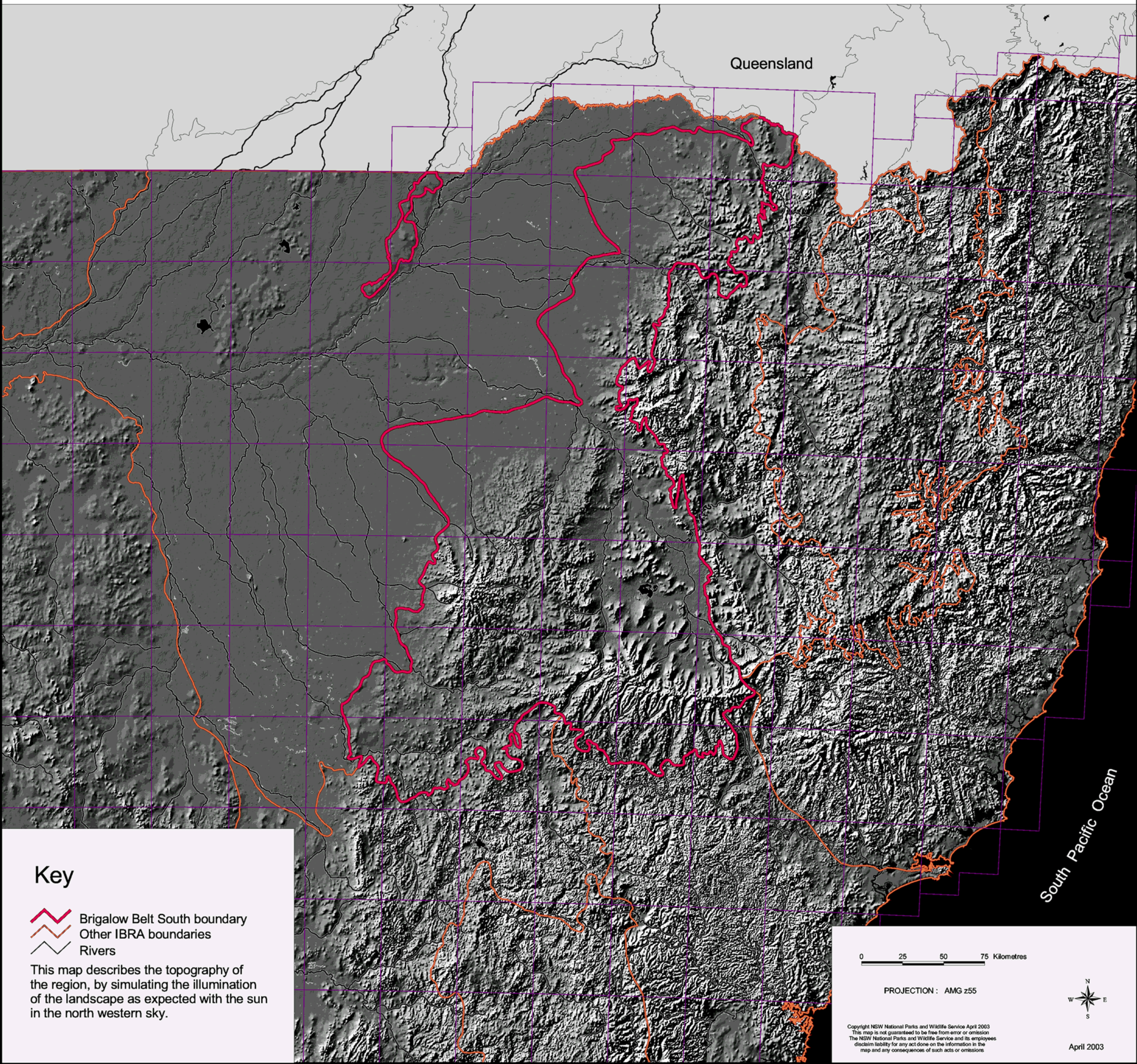
April 2003

Brigalow Belt South Biogeographic Region (IBRA) - Rivers



April 2003

Brigalow Belt South Biogeographic Region (IBRA) - Topography



Key

Brigalow Belt South boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

0 25 50 75 Kilometres

PROJECTION : AMG z55

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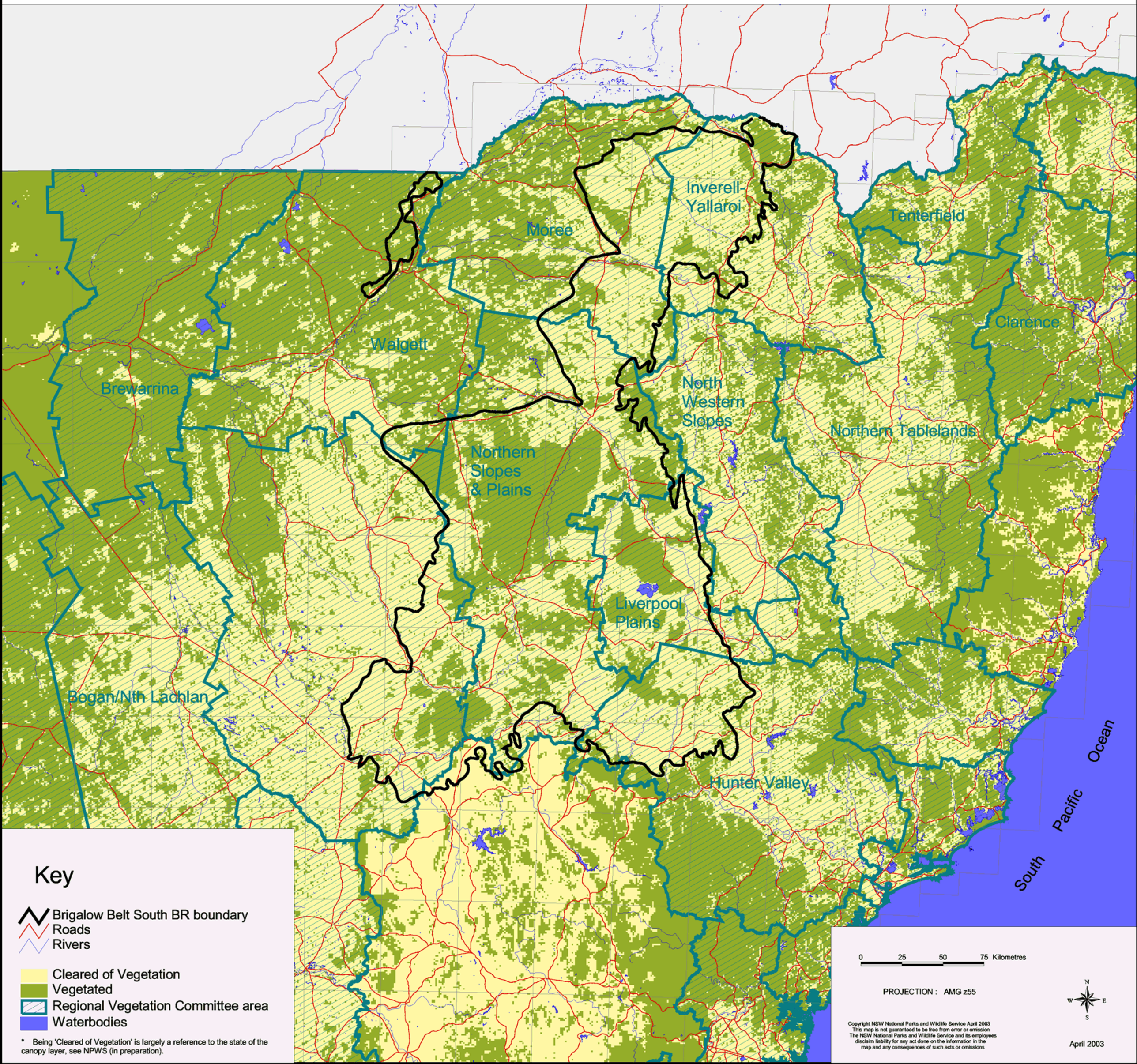
April 2003

Brigalow Belt South Biogeographic Region (IBRA) - Vegetation



Key

- Brigalow Belt South BR boundary
- Roads
- Rivers

- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Brigalow Belt South Biogeographic Region (IBRA) - Tenure/Reserves

Queensland

South Pacific Ocean

Key

- Brigalow Belt South BR boundary
- IBRA regions in NSW
- Roads
- Rivers
- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

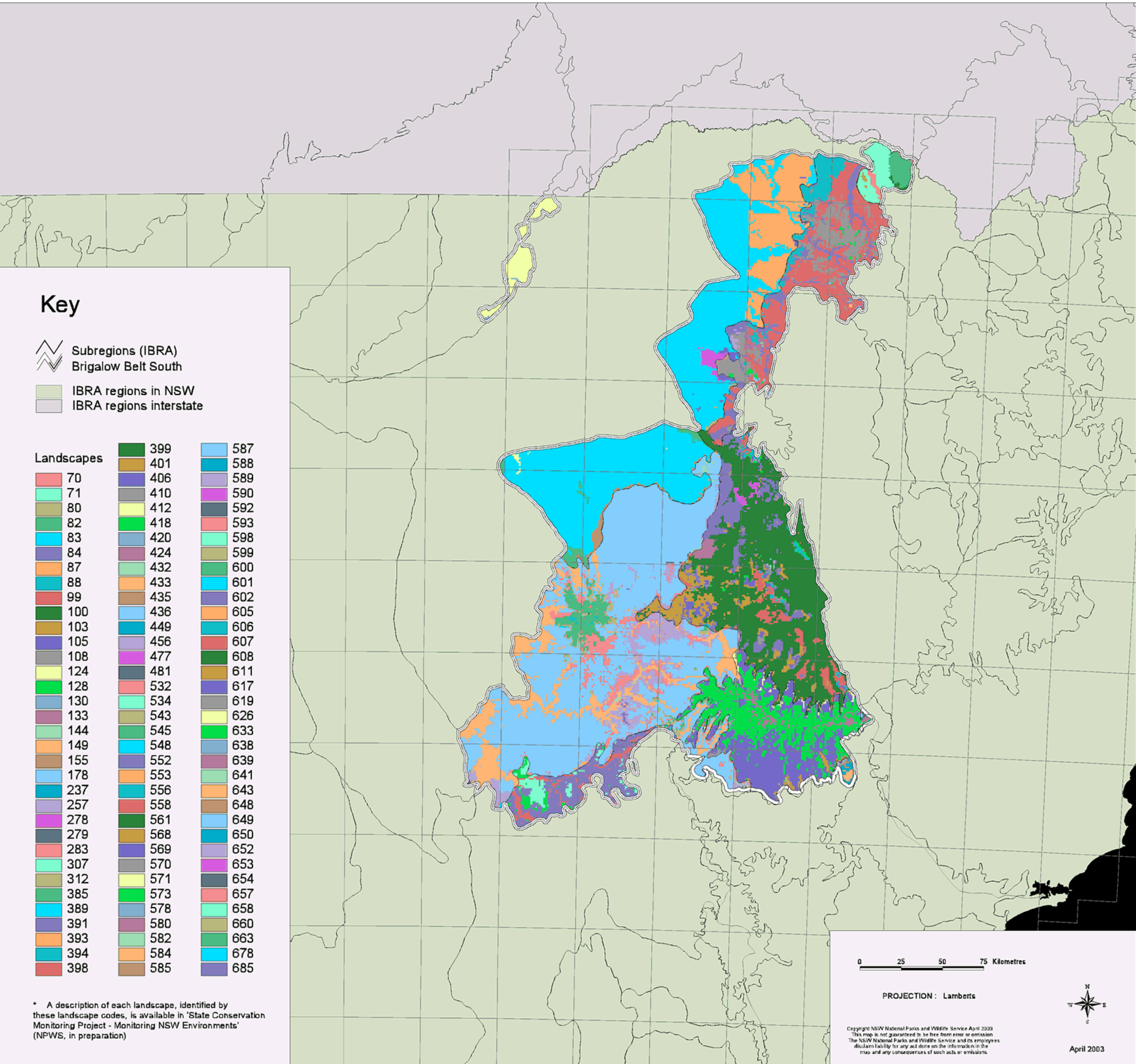
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Brigalow Belt South Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)



* A description of each landscape, identified by these landscape codes, is available in 'State Conservation Monitoring Project - Monitoring NSW Environments' (NPWS, in preparation)

CHAPTER 12

The Nandewar Bioregion

1. Location

The Nandewar Bioregion lies in northern NSW and across the Qld border. The bioregion is bounded by the North Coast, New England Tablelands and Brigalow Belt South bioregions in the south, east and west respectively. It spans an area of 2,700,313 ha, with 2,069,604 ha or 76.6% of it falling in NSW and occupying 2.59% of the state.

The bioregion encompasses Inverell and Tamworth and the smaller towns of Quirindi, Bingara, Barraba, Manilla and Bendemeer.

Part of the MacIntyre, Gwydir and Namoi catchments are located in the bioregion, and the Peel, Macdonald, McIntyre, Namoi, Severn and Gwydir Rivers traverse the bioregion.

2. Climate

The Nandewar Bioregion is considered mostly to be fairly warm and dry, although average annual temperatures and rainfall vary markedly across the bioregion in relation to elevation (NSW NPWS 2000). The central areas, such as the Nandewar Range and the northern slopes of the Liverpool Range, are generally cooler as they tend to have a higher elevation, whereas the warmer areas correspond to the lowlands around the main river catchment areas.

Average annual rainfall also varies distinctly across the bioregion. It is characterised by frequent rains of high intensity and high run-offs caused by the steep slopes and shallow soils that feature prominently in the bioregion (Morgan and Terrey 1992). Rainfall generally decreases from east to west, but the differing topography across the bioregion alters this trend somewhat, with areas at higher altitudes, such as Mt Kaputar, receiving significantly more rain annually than lower lying areas in the west (NSW NPWS 2000). The Nandewar Bioregion is subject to summer rainfall (Benson 1999), with the rainfall pattern described as being slightly summer dominant (Morgan and Terrey 1992).

3. Topography

The Nandewar Bioregion is formed on Palaeozoic sedimentary rocks on the western edge of the New England Tablelands and includes the Tertiary basalts of Inverell and Kaputar. The hilly landscapes are warmer but drier than the tablelands and carry vegetation communities more typical of the western slopes, with some tableland species.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
10 – 18°C	-3.5 – 3.6°C	22.9 – 34.7°C	566 – 1270mm	31 – 83mm	76 – 137mm

4. Geology and geomorphology

The New England Fold Belt is the youngest structural feature in NSW and is separated from the Lachlan Fold Belt by the Sydney-Bowen Basin that is filled with Mesozoic sediments. The oldest rocks in the sequence are Devonian sedimentary and volcanic rocks, formed in an island arc environment. The youngest are Triassic sandstones and shales deposited by rivers on the edge of the Gunnedah Basin, about 250 million years ago, at a time when New England was being lifted by intrusions of granite.

Major volcanic eruptions occurred in two phases: in the lava field flood basalts of the Inverell area (34-32 and 22-19 millions of years ago), and in a central volcano similar to that in the Nandewar Ranges (21-17 million years ago). The maximum preserved thickness of the flows is 800m in the variety of lavas present. Only the core of the Nandewar volcano remains as exposed plugs and dykes. Flows from the New England centres buried river gravels and lake sediments that are now being exposed and contain deposits of tin, sapphires and diamonds.

A narrow strip of ultrabasic rocks, including serpentinites that are derived from a deep ocean floor, marks the suture where a former island arc complex was linked to the Australian mainland. These rocks pass through Woodsreef and Tamworth where they are associated with limestones in which karst landscapes are formed. The composition of these rocks is so unusual that they always have distinct soils and vegetation.

Geomorphically, the western slopes can be seen as a dissected ramp that links the uplifted highlands with the western plains. Western rivers pass across the ramp without depositing large volumes of sediment and the Darling Riverine Plains alluvial fans begin at the base of the ramp.

5. Geodiversity

The broad geologic features of these environments can be seen in other parts of the western slopes and Great Dividing Range but particular features of note include the following:

- the volcanic landforms of Mt Kaputar and the cold-tolerant vegetation found on it;
- the karst landscape features at Ashford Caves and near Tamworth;
- rare geology of the serpentinites with unusual mineralisation, soils and vegetation, including heritage elements of a former asbestos mine at Woods Reef;
- sub-basaltic drainage patterns in the Inverell basalts, the occurrence of leaf fossils, gemstones and tin and the associated mining heritage; and
- the granite tor topography and deep gorge of the Severn River near Ashford.

6. Soils

The bioregion is characterised by clay or loam soils, but siliceous soils derived from acid volcanic rocks are also found.

On the sedimentary rocks, shallow stony soils occur on ridges passing to texture contrast soils on almost all slopes. These change in colour from red brown subsoils on upper slopes to yellow subsoils on lower slopes. They support diverse vegetation communities that are also affected by altitude.

The granites develop gritty shallow profiles between outcrops and tors on the crests, grading to harsh texture contrast soils with yellow clay subsoils that are prone to gully development on the lower slopes.

Basalt areas on Kaputar have frequent rock outcrops interspersed with shallow, stony, brown loams. Black earths are found on lower slopes and in valleys.

In the Inverell area the basalts develop black earth profiles that thicken downslope and, where the underlying sands and gravels are exposed, the coarse sandy soils may develop podsol pans and support different vegetation. Alluvial loams and clays with moderate to high fertility are found in the valleys.

Dark, alkaline, pedal clays develop on limestone, and the serpentinites have shallow stony profiles with concentrations of elements that are toxic to many plants.

7. Biodiversity

7.1 Plant communities

The vegetation of the Nandewar Bioregion is influenced primarily by geology and the influence of altitude on temperature and rainfall. The bioregion is characterised by box woodlands that occur on clay or loam soils, typically at low to mid elevation in agriculturally productive areas. The principal dominants of these box woodlands are white box (*Eucalyptus albens*), yellow box (*Eucalyptus melliodora*), Blakely's red gum (*Eucalyptus blakelyi*) and grey box (*Eucalyptus mollucana*). Bimbil box (*Eucalyptus populnea subsp. bimbil*), fuzzy box (*Eucalyptus conica*) and western grey box (*Eucalyptus microcarpa*) also occur, particularly in the western half of the bioregion.

With decreasing soil fertility and increasing topographic relief the box woodlands are replaced by ironbark/cypress pine communities which characterise much of the agriculturally less productive parts of Nandewar. These communities are common at mid elevations, particularly on sedimentary hills and ranges, and form woodlands and open forests typically consist of silver-leaved ironbark (*Eucalyptus melanophloia*), white cypress pine (*Callitris glaucophylla*) and tumbledown red gum (*Eucalyptus dealbata*). Canopy combinations vary in relation to environmental factors, with narrow-leaved ironbark (*Eucalyptus crebra*) common on sediments and Caleys ironbark (*Eucalyptus caleyi*) and black cypress pine (*Callitris endlicheri*) favouring granitic areas. White box and stringybarks can be additional components of the ironbark/cypress pine communities, and in localised areas form associations with mugga ironbark (*Eucalyptus sideroxylon*), an important habitat resource for fauna.

At mid to high elevations in mountainous terrain, forests of silver-top stringybark (*Eucalyptus laevopinea*), manna gum (*Eucalyptus viminalis*) and mountain gum (*Eucalyptus dalrympleana subsp. heptantha*) occur. Montane woodlands and sub-alpine forests of snow gum (*Eucalyptus pauciflora*), mountain gum, manna gum and rough-barked mountain gum (*Eucalyptus volcanica*) occur at high elevation on Mt Kaputar.

Riparian forests of river oak (*Casuarina cunninghamiana*), sometimes with river red gum (*Eucalyptus camaldulensis*), occur along the major watercourses, with Blakely's red gum and rough-barked apple (*Angophora floribunda*) forming the common association along minor drainage lines. Forest and woodlands of northern smooth-barked apple (*Angophora leiocarpa*) and dirty gum (*Eucalyptus chloroclada*) are associated with sandstone parent material on the north-western edge of the bioregion.

Basalt-derived soils around Inverell support vegetation dominated by white box and silver-leaved ironbark grading to yellow box, rough-barked apple, Blakely's red gum and white cypress pine on lower slopes. Manna gum can occur in the valleys with river oak along the streams.

Vegetation communities on limestone and serpentinite sites are usually floristically distinct from adjacent areas. Large grass trees (*Xanthorrhoea* sp.) can be a prominent feature of such sites. Serpentinite areas are botanically important as they support endemic flora and currently undescribed species, including a red stringybark, which together with spinifex hummock-grass dominates several sites.

The Nandewar Bioregion also supports small patches of dry rainforest vegetation including the endangered ecological communities – semi-evergreen vine thicket and ooline. Other endangered ecological communities in the bioregion include the much depleted white box/yellow box/Blakely's red gum and brigalow woodlands, Howell shrublands, McKie's stringybark open forest and minor occurrences of native grasslands on cracking clays in the bioregions southwest.

At least two-thirds of the original cover of woody vegetation in the bioregion has been cleared and less than 2% is protected in conservation reserves. Vegetation clearance remains a significant threat to biodiversity across the bioregion. Coolatai Grass (*Hyparrhenia hirta*), an invasive species, is threatening to displace the indigenous ground flora of large tracts of grassy box woodlands, derived native grasslands and granite woodlands.

7.2 Significant flora

More than 60 rare or threatened species have been recorded from the Nandewar Bioregion. This includes 18 species listed under the NSW TSC Act 1995, 9 of which are considered as endangered and 9 vulnerable. The remainder are rated as rare or threatened at a national scale (Briggs and Leigh 1995). Two of these, *Euphrasia arguata* and *Euphrasia ruptura*, are now thought to be extinct.

The major threats to these species continue to be vegetation clearance and habitat fragmentation and disturbance. Species such as *Digitaria porrecta*, and *Cadellia penstalylis*, are seriously threatened by weed invasion and pasture improvement of native grasslands.

The Nandewar Bioregion supports many other plant species of conservation significance such as the serpentinite endemics and presently undescribed taxa, for example members of the *Macrozamia* and *Homoranthus* genera.

Photo: NPWS

7.3 Significant fauna

Four hundred and sixty seven vertebrate species are known to occur in the bioregion. Of these, 134 species, or almost one-third, are considered to be of conservation significance and 51 of these are listed as extinct, endangered or vulnerable in the TSC Act. Protection of the remnant vegetation of the Nandewar Bioregion is critical to the survival of these species.

Several frogs are considered to be of extremely high conservation significance in the bioregion, having declined in distribution. These include *Litoria booroolongensis* and *Adelotus brevis*, both of which are now extremely rare in the bioregion.

One turtle species, *Elseya bellii*, is listed as a threatened species and found on the upper reaches of the Gwydir, Namoi and Macdonald rivers. It is considered to be of high conservation significance in the Nandewar Bioregion. Very little is known about turtle distribution in the bioregion in general, including that of *Chelodina expansa*, which has secretive habits and is usually found in muddy water (Cann and Ward 1998).

Twelve lizard species are considered to be of conservation significance, including *Anomalopus mackay* and *Underwoodisaurus sphyrurus*. Two-thirds of the records for the latter occur in the Nandewar Bioregion.

Half of the 26 snake species of the bioregion are considered to be of conservation significance. This may be partly due to the lack of data for the bioregion. Among these, *Holocephalus bitoquatus* is known from historical records in the bioregion but there have been no records of recent sightings.

There is a high diversity of woodland birds in the Nandewar Bioregion, including significant populations of a number of threatened species, such as the turquoise parrot (*Neophema pulchella*), brown treecreeper (*Climacteris picumnus*), speckled warbler (*Chthonicola sagittatus*), diamond firetail (*Emblema guttata*), grey-crowned babbler (*Pomatostomus temporalis*) and hooded robin (*Melanodryus cucullata*). Of the 252 diurnal bird species of the bioregion, 45 are of conservation significance and 18 of these are listed in the TSC Act.

The Nandewar Bioregion, together with the New England Tableland Bioregion, supports a significant proportion of the NSW population of the regent honeyeater (*Xanthomyza phrygia*). Declines in the numbers of ground-feeding insectivores, grassland and freshwater birds and some temperate woodland birds are evident in the bioregion.

Populations of musk lorikeets (*Glossopsitta concinna*) have increased in this and the New England Tableland Bioregion, as have little corella (*Cacatua sanguinea*) populations (Australian Terrestrial Biodiversity Assessment 2002), while 6 of the 11 nocturnal birds of the bioregion, including several owls and the bush stone-curlew (*Burhinus grallarius*), are considered to be of conservation significance.

Six of the 9 native arboreal mammals of the bioregion are of conservation significance, including the koala (*Phascolarctos cinereus*) which although widespread relies on remnant forest in the bioregion. The bioregion also supports high density populations of squirrel glider (*Petaurus norfolcensis*). The greater glider (*Petauroides volans*) is an example of the disjunct faunal populations found in Mt Kaputar National Park.

Fourteen of 27 bats in the bioregion are also of conservation significance, including some of the rarest bats in north-eastern NSW such as *Vespadelus troughtoni* and *Chalinolobus dwyeri*, which are known from several locations in the bioregion.

7.4 Significant wetlands

There were no significant wetlands recorded for this bioregion (Australian Terrestrial Biodiversity Assessment 2002).

8. Regional history

8.1 Aboriginal occupation

The Aboriginal language groups whose traditional lands lie in the Nandewar bioregion include the Anaiwan (south of Inverell, west to Tingha, to Armidale and south of Uralla), Kamilaroi (from Liverpool Plains to Gwydir; Walgett, Bingara, Quirindi), the Weraerai (Wirrayaraay) and the Kwaimbul in the north.

Aboriginal people used the landscape as both a natural and cultural resource. Evidence of "transient campsites", (noted by Mitchell as being distributed among the casuarinas and acacias) suggested a seasonal approach to hunting and gathering activities. A range of stone tools were developed with local and traded stone, including "greywackes" and quartz. Mammals such as kangaroo and possum were used for food, clothing, decoration, and stone and wooden hunting tools such as jagged spears, boomerangs and waddies were developed to catch them. Fish were trapped and taken from Gwydir using stone weirs and nets made from plant fibre.

The landscape has influenced the names of many of the local towns and stations which are named after Aboriginal words for aspects of the landscape, usually in association with water which is an important resource in dry country. Bingara – "creek" or "shallow crossing", Barraba – "camp by the riverbank", Manilla – *muneela* – "winding river", Quirindi – *guyerwarindi* – "waters fall together". The region is known for ornately carved trees, ceremonial bora grounds and art sites, indicating an intimate spiritual, as well as a physical, attachment to the sacred landscape the Aboriginal people inhabited.

The region is also the place of a marked history of conflict between Aboriginal and non-Aboriginal people. The Europeans pushed the indigenous community away from creeks and waterholes and seized the women and girls. The Aboriginal men retaliated by spearing stock and attacking the stations. In response, several organised massacres took place in the region, including the infamous Myall Creek massacre. At this place, nearly 28 Wirrayaraay, reputedly a peaceable community, were gruesomely murdered at their camp by 11 local stockmen and station hands who were later hanged for their crime. A memorial to those who once lived there now stands as a reminder to passers by.

8.2 European occupation

John Oxley explored the northern tablelands including the Nandewar Bioregion in 1818. Squatters began to occupy the area in the 1830s, looking for suitable grazing land (NSW NPWS 1991). Inverell, on the eastern border of the bioregion, originated in 1837 as a 50,000-acre station run by Alexander Campbell (HO and DUAP 1996).

Cattle grazing was the dominant land use of the bioregion in the early days of European settlement but by the end of the 1800s sheep grazing was expanded due to improved pastures and better fencing (NSW NPWS 1991).

The gold rush of the 1850s led to the rapid entrenchment of several towns in the Nandewar Bioregion. Goldfields in the centre of the bioregion saw the origin of the town of Barraba in 1852, which later became a centre of wheat and pastoralism and was also supported by the Woods Reef Asbestos mine until it closed in 1982 (HO and DUAP 1996). Similarly, Bingara began as a small village until gold was discovered nearby and the All Nations Gold Mine, active from 1880 to 1948, ensured its permanence. Diamonds representing most of Australia's yield were also mined near Bingara (HO and DUAP 1996). Inverell benefited from the surrounding mines and sapphire mining also became a basis for the town's economy for several years. The fertility of its soils allowed increased farm yields in order to feed the miners.

The Liverpool Plains supported the estates of the Australian Agricultural Company from 1832 (HO and DUAP 1996), when the squatters were driven further north. The company's headquarters became the basis of the town of Tamworth when urban development began to occur in earnest in the 1850s. By 1861 Tamworth had a population of 654 people and became a link in the traffic route from the north, especially when the railway reached the town in 1873 (HO and DUAP 1996). Tamworth became a municipality in 1876 and by this time it was a successful town with much industry and facilities such as a hospital, banks and schools. In 1888, after building its electricity generating plant (NSW NPWS 1991), Tamworth became the first town in Australia to use electric lighting (HO and DUAP 1996) and eventually it serviced much of the north of the state.

Inverell was not planned as a town until 1858, and later thrived as a result of agricultural production, particularly wheat, with the advent of more sophisticated equipment introduced in the 1860s and 1870s. The railway reached Quirindi in 1877 and by the 1890s this area too was a major wheat centre (HO and DUAP 1996).

Soft wood timber was abundant in the bioregion although it was difficult to retrieve. Many forests were dedicated as state forests around 1900 and most are still managed by State Forests of NSW (NSW NPWS 1991).

9. Bioregional-scale conservation

A small proportion (43,038.72 ha, or 2.07%) of the NSW part of the Nandewar Bioregion is managed under various conservation regimes. Of these, the majority is land managed under the provisions of the NPW Act 1974 as national parks or nature reserves. These occupy 40,657.46 ha or 1.97% of the bioregion. These parks and reserves include Kwiambal National Park, which is almost entirely within the bioregion, as is the majority of Mt Kaputar National Park. Three wilderness areas (Wilderness Act 1987) Grattai, Nandewar and Rusden have been declared over Mt Kaputar National Park, and together occupy 28,790.73 ha or 1.39% of the bioregion. The Torrington State Recreation Area takes up only a small portion of the Nandewar Bioregion, occupying 11.32 ha or 0.001% of the bioregion, the largest portion falling in the adjacent New England Tableland Bioregion. There are no Aboriginal areas, no historic sites, no reserves, no state recreation areas and no regional parks in the bioregion.

No voluntary conservation agreements have been entered into with landholders, but there are 3 wildlife refuges that occur on properties occupying 1,890.48 ha or 0.09% of the bioregion. Landholders on 4 properties have entered into property agreements (NVC Act 1997). The conservation zone of these agreements occupies 137.06 ha or 0.01% of the bioregion.

One flora reserve, Mehi, is managed under the provisions of the Forestry Act 1916, and occupies 48.77 ha or 0.002% of the bioregion. State forests managed primarily for forestry activities under the Forestry Act 1916 occupy 41,625.31 ha or 2.01% of the bioregion.

10. Subregions of the Nandewar Bioregion

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Peel	Fine grained Silurian to Devonian sedimentary rocks. Strongly folded and faulted with marked northwest alignment. Areas of sub-horizontal Carboniferous shales and sandstones in the north. Limited areas of basalt cap from the Nandewar and Liverpool Ranges are included. Linear outcrops of serpentinite and scattered bodies of limestone.	Low peaked hills with north-westerly alignment. Basalt caps of dissected flows, moderate slopes and flat river valleys with alluvium. Karst landscapes in limestone.	Shallow stony soils on ridges. Texture contrast soils on almost all slopes shifting in colour from red brown on upper slopes to yellow on lower slopes. Black earths on basalt. Dark, alkaline, pedal clays on limestone. Serpentinites have shallow stony profiles with concentrations of elements that are toxic to many plants. Alluvial loams and clays with moderate to high fertility in alluvium.	White box grassy woodlands, with yellow box and Blakely's red gum on lower slopes. Rough-barked apple and yellow box on flats. River oak and some river red gum along major streams. Patches of red stringybark and red ironbark on steeper slopes in the east. Silver-leaved ironbark on basalt caps, white cypress pine and kurrajong on stony areas in the west and north. Very large grass trees on serpentinite.
Kaputar	Remains of a Tertiary central volcano with a thick sequence of basaltic lavas.	Rugged steep rocky hills and peaks, exposed volcanic plugs and dykes. Benched slopes mark different lava flows.	Frequent rock outcrop interspersed with shallow stony brown loams. Black earths on lower slopes and valleys.	Snow gum and manna gum on the highest tops with silver-topped stringybark, broad-leaved stringybark and red stringybark. Black cypress pine and white cypress pine with silver-leaved ironbark, narrow-leaved ironbark on slopes. Kurrajong, yellow box, white box, rough-barked apple and Blakely's red gum on lower slopes.
Inverell Basalts	Extensive basalt flows from a Tertiary lava field eruption centre. Tertiary sub-basaltic sands and gravels exposed at the edges of the flows. Small areas of granite and Palaeozoic and Mesozoic sandstones.	Undulating low hills and the dissected edge of the New England Plateau. Long hillslopes are stepped across different lava flows and have a marked break of slope where buried sands and gravels are exposed.	Soils on sedimentary rocks similar to Peel Subregion. Brown to black pedal loams and clays on basalts thickening downslope, high nutrient levels and excellent water holding capacity. Exposed Tertiary sands have coarse sandy soils that may develop podsol pans.	White box with silver-leaved ironbark and red ironbark. Yellow box, rough-barked apple and Blakely's red gum and white cypress pine on lower slopes. Manna gum in valleys and river oak on streams.
Northern Complex	Large areas of coarse grained granite and gently folded Carboniferous quartz sandstones and shale. Isolated limestone outcrops.	Low hills and ranges, more rugged on granites with abundant rock outcrop and tors. Short, steep gorges of major rivers. Karst landscapes on limestone.	Harsh texture contrast soils with subsoils prone to gully development. Gritty shallow profiles on granite. Dark, alkaline, pedal clays on limestone.	Red ironbark with white cypress pine, grey box, forest red gum, and bull oak on granites. Lower colluvial slopes as above with pale bloodwood, and hill red gum. River red gum, river oak and rough-barked apple on creeks. Silver-leaved ironbark and white cypress pine on shale and sandstone with white box on lower slopes. Poplar box, brigalow. Bulloak on finer alluvium, forest red gum and Moreton Bay ash on coarser alluvium. Diverse understorey shrubs.

11. References

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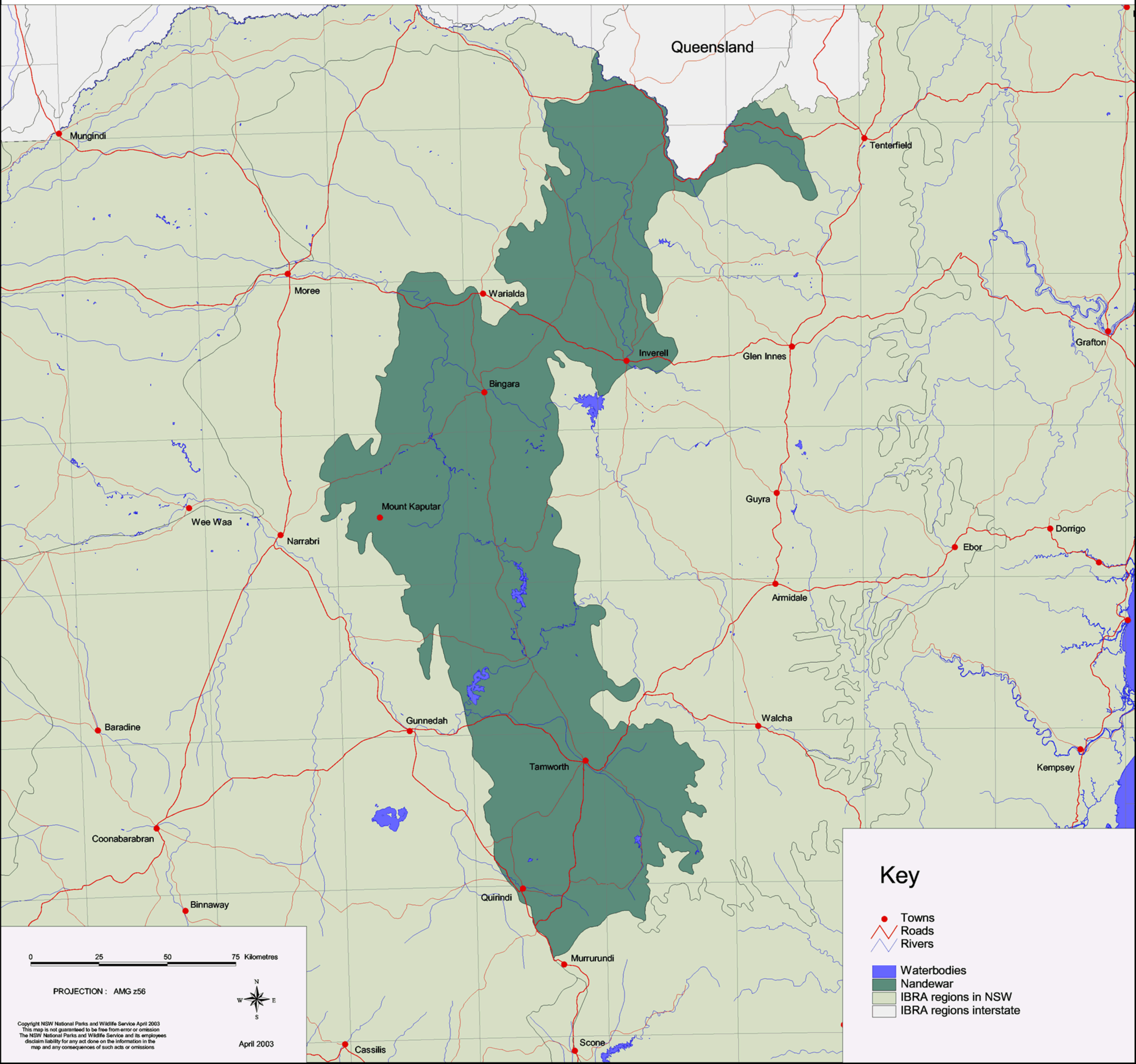
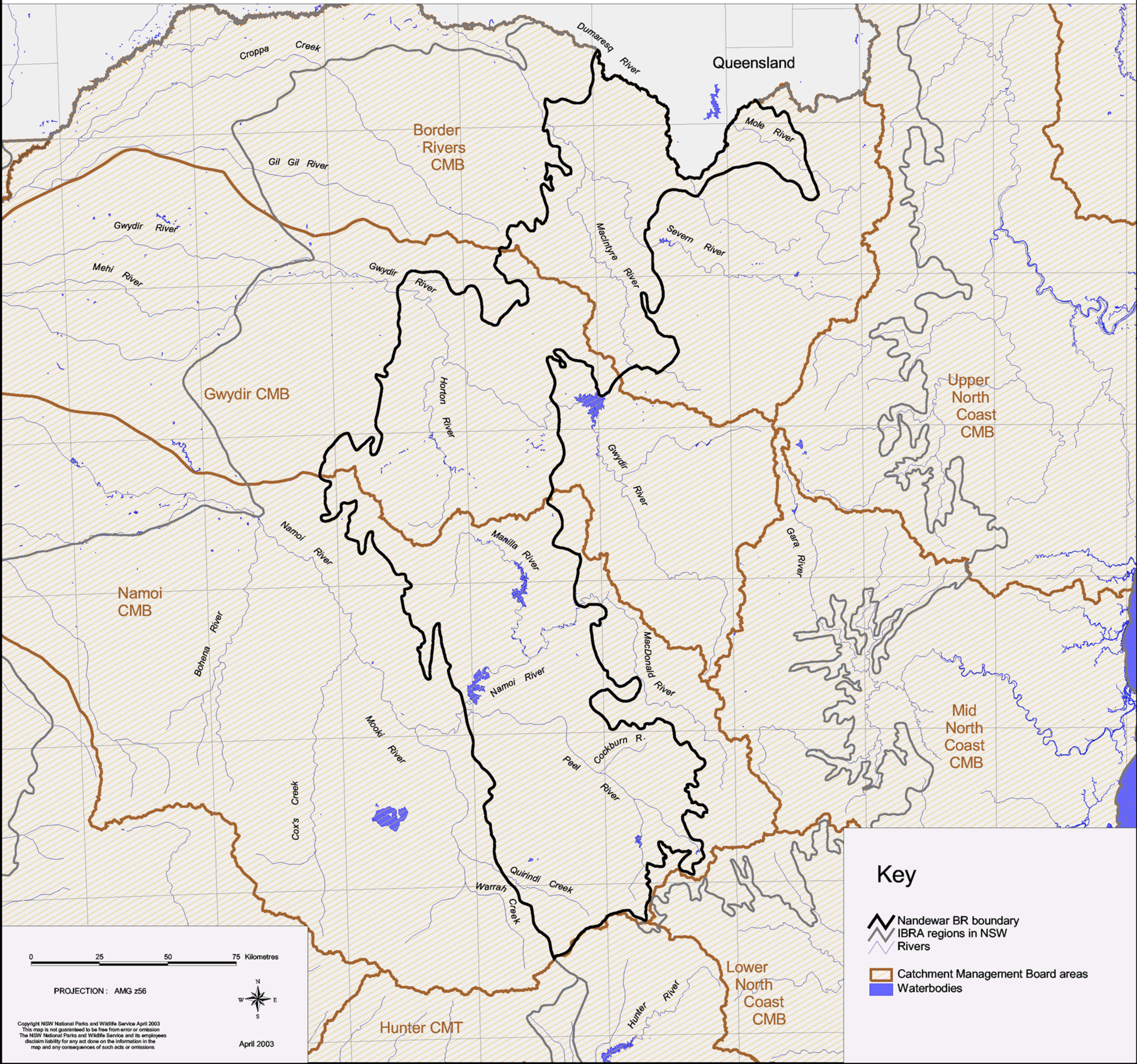
Photo: C. Perry

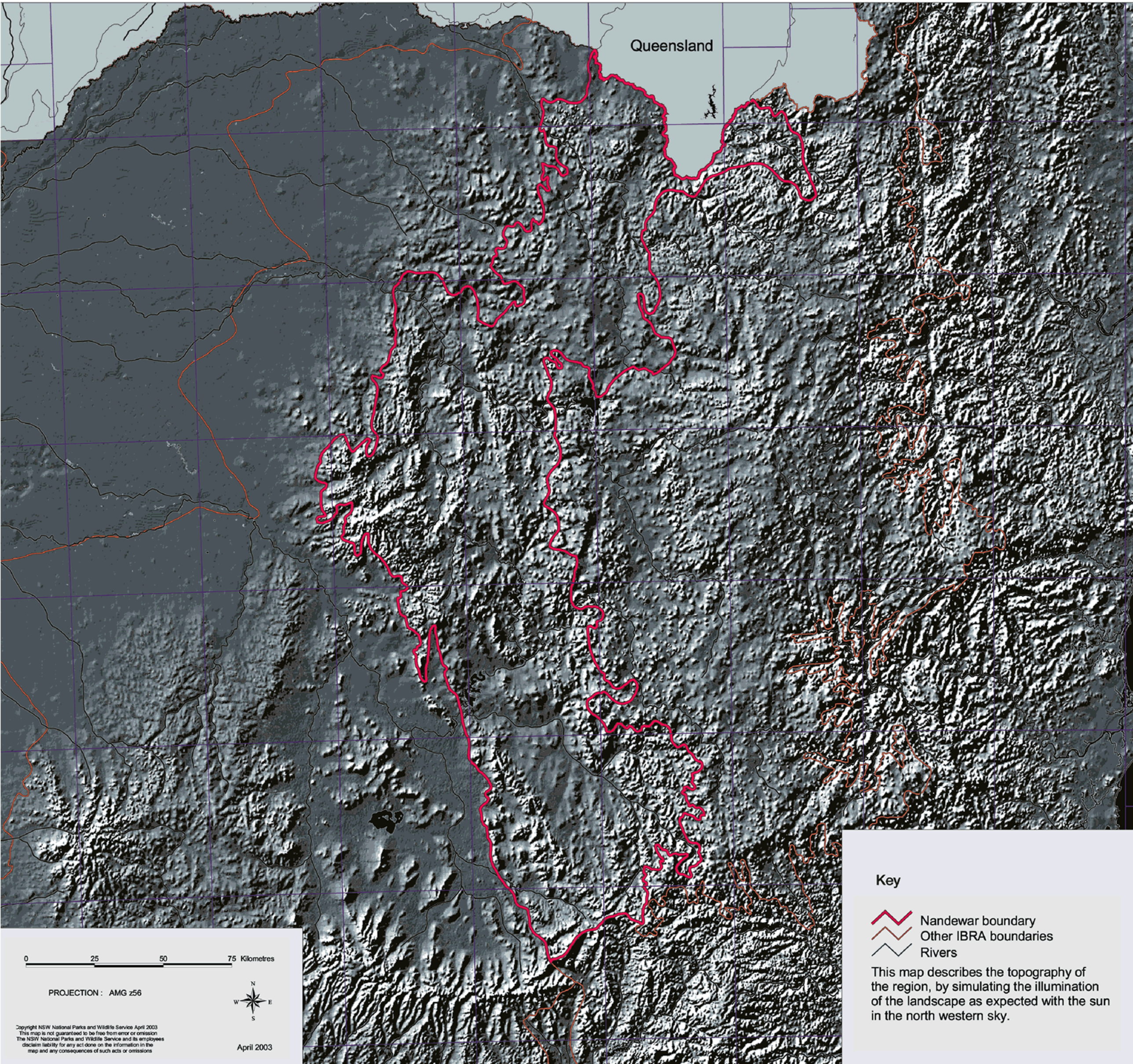
Nandewar Biogeographic Region (IBRA) - Location



Nandewar Biogeographic Region (IBRA) - Rivers



Nandewar Biogeographic Region (IBRA) - Topography



0 25 50 75 Kilometres

PROJECTION : AMG z56

N
W E
S

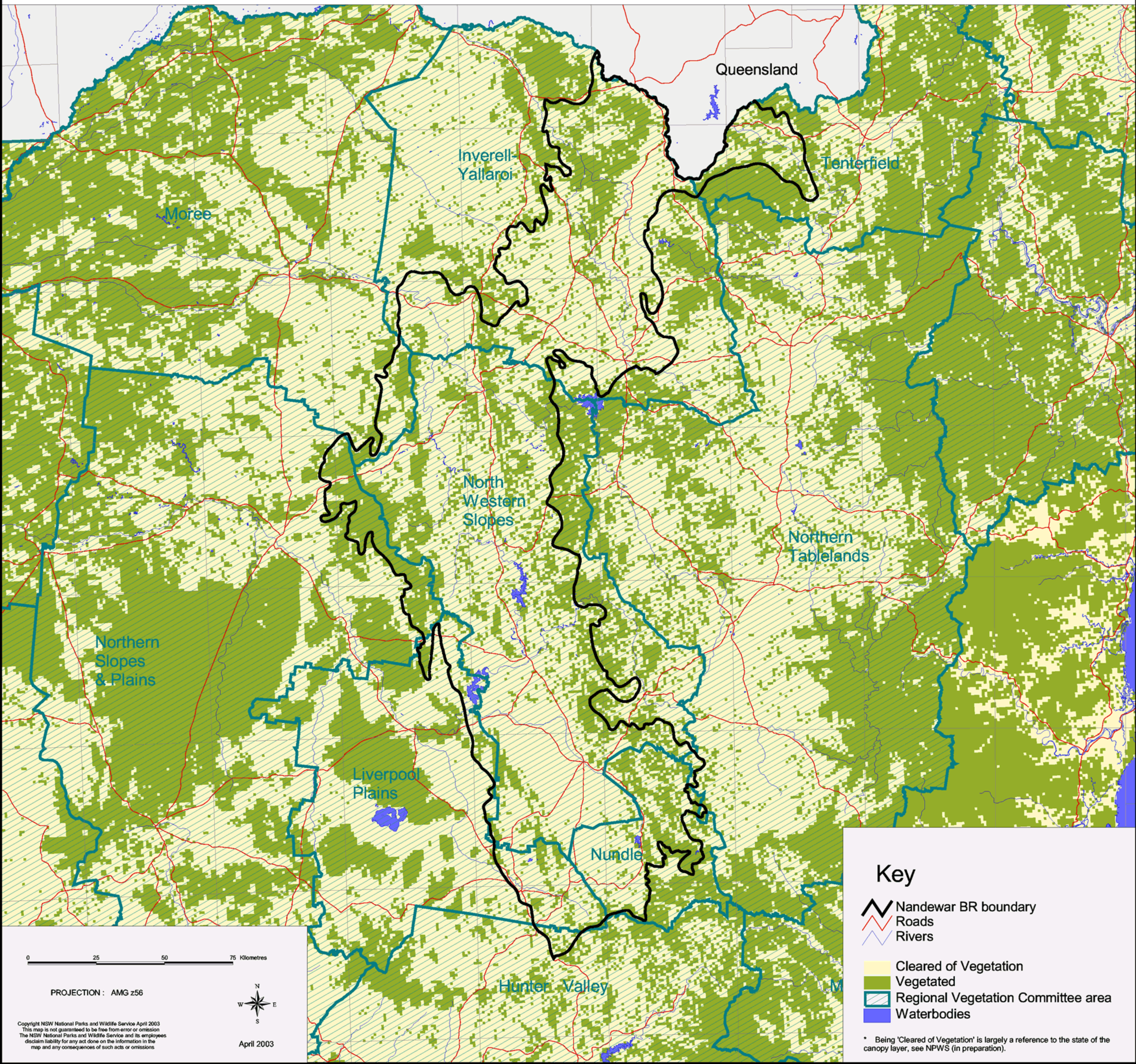
April 2003

Key

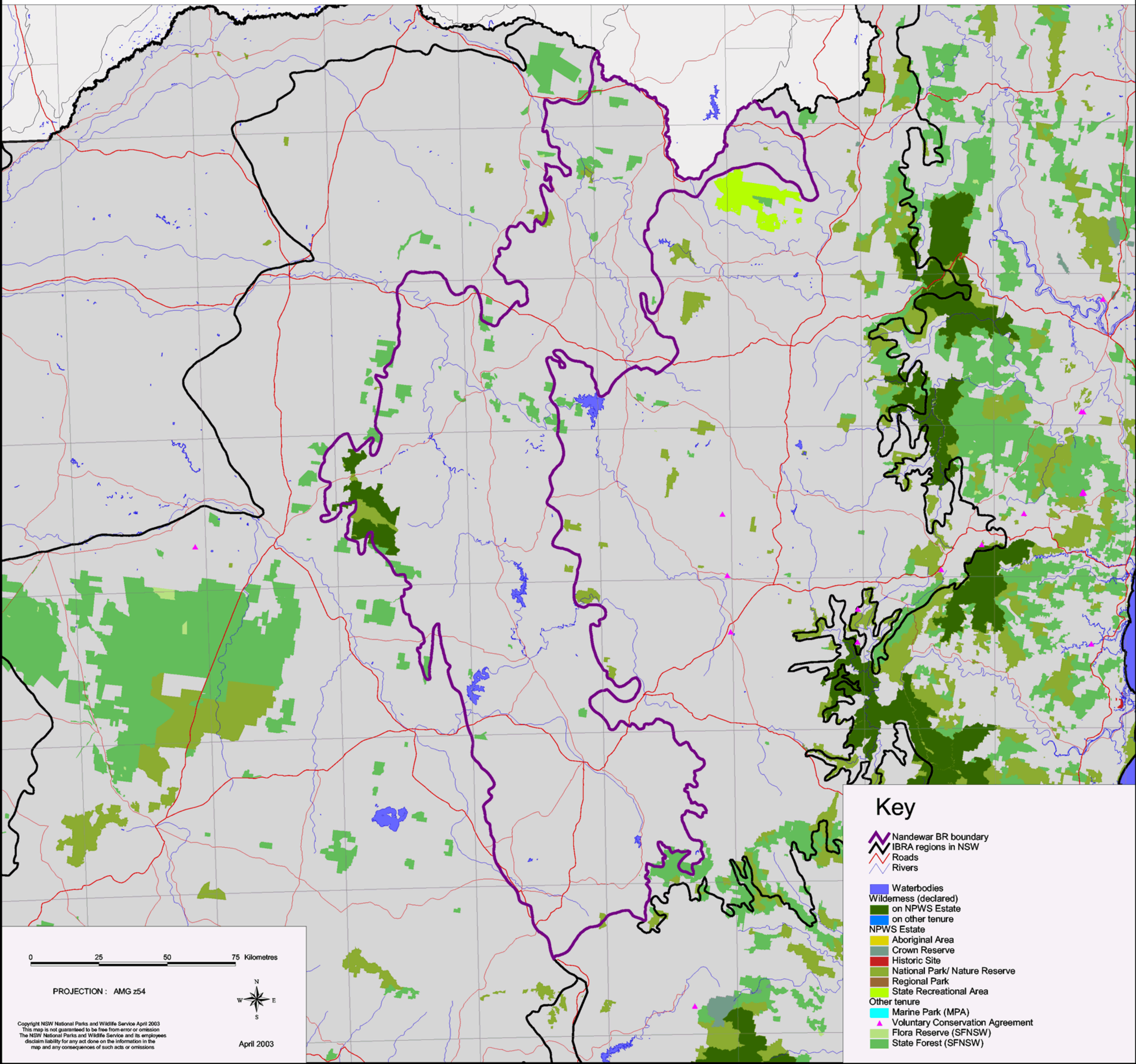
Nandewar boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

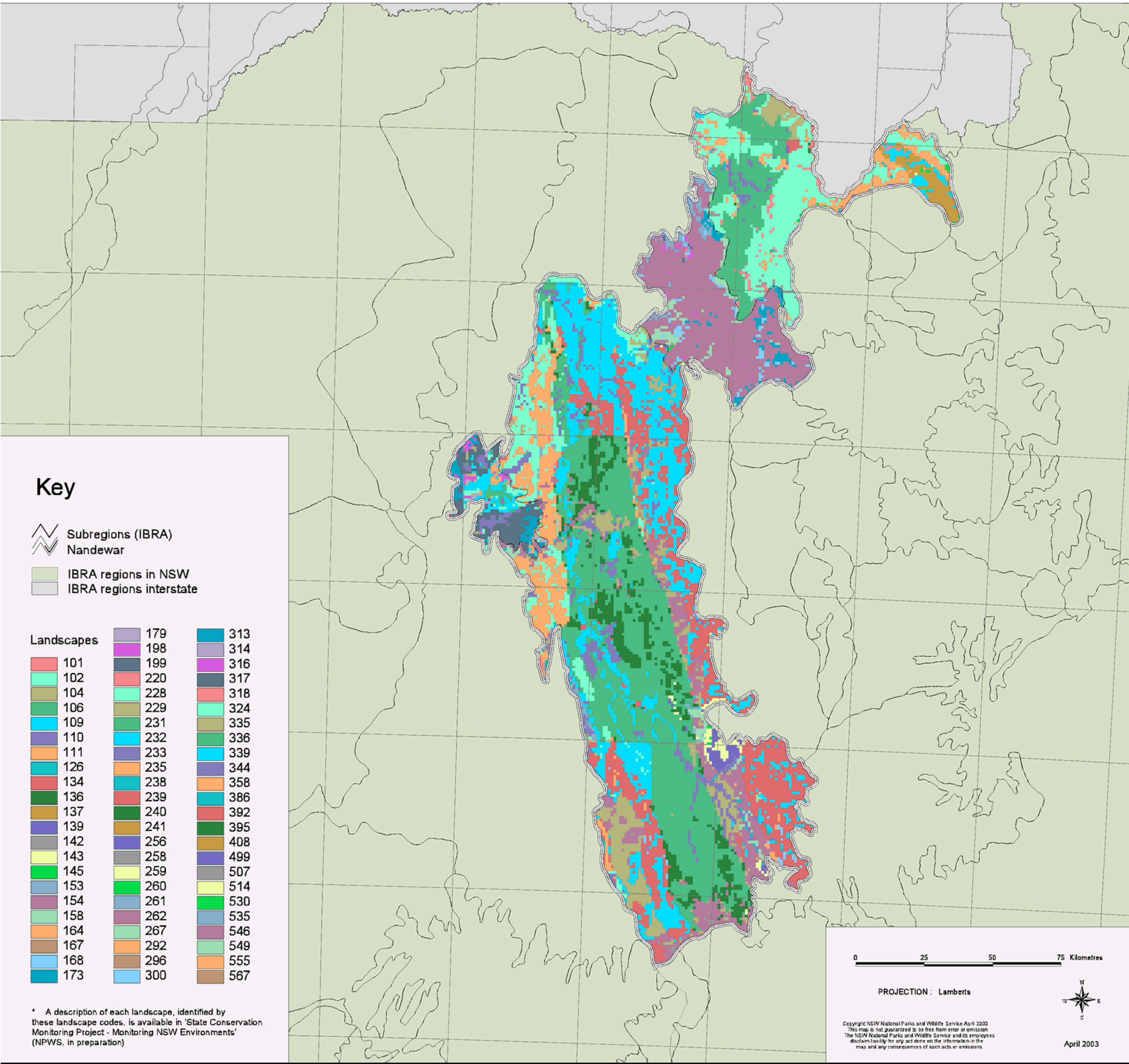
Nandewar Biogeographic Region (IBRA) - Vegetation



Nandewar Biogeographic Region (IBRA) - Tenure/Reserves



Nandewar Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)



Key

Subregions (IBRA)
Nandewar

IBRA regions in NSW
IBRA regions interstate

Landscapes

101	179	313
102	198	314
104	199	316
106	220	317
109	228	318
110	229	324
111	231	335
126	232	336
134	233	339
136	235	344
137	238	358
139	239	386
142	240	392
143	241	395
145	256	408
153	258	499
154	259	507
158	260	514
164	261	530
167	262	535
168	267	546
173	292	549
	296	555
	300	567

* A description of each landscape, identified by these landscape codes, is available in 'State Conservation Monitoring Project - Monitoring NSW Environments' (NPWS, in preparation)

0 25 50 75 Kilometres

PROJECTION : Lamberts

N W E S

April 2003

CHAPTER 13

The New England Tableland Bioregion

1. Location

The New England Tableland Bioregion has an area of 3,004,202 ha of which 2,860,758 ha or 95.23% of the bioregion lies within NSW. This bioregion is one of the smaller bioregions in NSW, occupying 3.57% of the state.

The bioregion lies between the North Coast and Nandewar bioregions in northeast NSW, extending north just into Queensland. In NSW, the bioregional boundary extends from north of Tenterfield to south of Walcha and includes towns such as Armidale and Guyra, with Inverell just outside the boundary.

The bioregion includes parts of the MacIntyre, Clarence, Gwydir, Macleay, Namoi and Manning River catchments.

2. Climate

The bioregion lies mainly in the temperate to cool temperate climate zone of NSW, which is characterised by warm summers, with uniform rainfall generally occurring in summer (Bureau of Meteorology website – http://www.bom.gov.au/). A warmer, sub-humid climate is present in the northeastern edge of the bioregion on the boundary of the North Coast Bioregion. Patches of montane climate occur at higher elevations, and these are characterised by mild summers and no dry season (Stern *et al.* 2000).

3. Topography

The New England Tableland Bioregion is a stepped plateau of hills and plains with elevations between 600 and 1500m on Permian sedimentary rocks, intrusive granites and extensive Tertiary basalts. Rainfall, temperature and soils change with topography and bedrock, and the vegetation is very diverse with a high degree of endemism.

4. Geology and geomorphology

The New England fold belt in the northeast of the state is composed of sedimentary rocks of Carboniferous and Permian age that were extensively faulted during a period of rapid continental plate movement associated with granite intrusions in the late Carboniferous. Much of the bedrock is now overlain by Tertiary basalt flows rarely exceeding 100m in thickness that lie on river gravels and sands or on lake sediments. As the basalt erodes the sands are exposed and have been mined for the sapphires, diamonds, gold and tin ore that they contain.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
9 – 17°C	-3.6 – 6°C	20.8 – 31.6°C	653 – 1765mm	31 – 86mm	83 – 304mm

The geology has a strong influence on topography. The eastern edge of the bioregion is at the Great Escarpment where coastal streams have cut deep gorges below the plateau. The granite country is steep with abundant boulder outcrops and rounded tors. The basalt country is more planar, except around former eruption centres that form high peaks and the individual basalt flows are seen as distinct levels across the plains. The basalts disrupted former drainage patterns and today the pre-basalt topography has been inverted with former valley floors, becoming ridge crests and hills. Large swamps and lagoons such as Llangothlin were partly created by these topographic changes.

During the Quaternary, colder climates had a major impact on vegetation patterns and allowed the formation of wind-blown lunettes on the eastern margins of the lagoons. Sediment in the lagoon floor preserves a pollen record of these changes.

5. Geodiversity

Important features include the following:

- the Great Escarpment with deep rugged gorges such as Apsley Gorge, and steep bouldery slopes on granite on the Moonbi Range;
- granite tor landscapes in many areas throughout the bioregion;
- scree slopes from high rocky peaks such as Ben Lomond may reflect cold climates of the past;
- disrupted drainage patterns and evidence of the development of a new system after the basalt eruptions;
- shallow swamps and lagoons such as Llangothlin and Mother of Ducks Lagoon contain valuable Quaternary pollen records in their sediments;
- pseudo-karst landforms occur in granite boulder streams; and
- heritage features associated with extensive mining of gold, tin and gemstones using techniques that were not common elsewhere in the state.

6. Soils

Siliceous sands derived from granites are found among rock outcrops. Red earths and mellow texture contrast soils of relatively low fertility and poor structure are widespread across the bioregion and are prone to erosion. Soils with increased organic matter occur in swampy sedgelands in valleys. These soils support a variety of open forests and woodlands.

In basalt areas, shallow stony loams are found on steep areas and deep, red brown and brown to black, fertile, well-structured loams are found on flatter slopes. Soils are sometimes waterlogged in valley floors. Siliceous sands and red earths occur on associated Tertiary sands and gravels.

Harsh texture contrast soils in the bioregion derived from Permian sedimentary rocks are generally yellow, thinner and stonier on steep slopes. Some areas of slightly saline soils also occur.

7. Biodiversity

7.1 Plant communities

Granitic soils derived from the prominent New England batholith support a variety of open forests and woodlands. These mainly consist of silver-top stringybark (*Eucalyptus laevopinea*), Blakely's red gum (*Eucalyptus blakelyi*), Youman's stringybark (*Eucalyptus youmanii*), yellow box (*Eucalyptus melliodora*), apple box (*Eucalyptus bridgesiana*), rough-barked apple (*Angophora floribunda*), black cypress pine (*Callitris endlicheri*), manna gum (*Eucalyptus viminalis*) and snow gum (*Eucalyptus pauciflora*).

Photo: Murray Robinson

The western slopes are dominated by tumbledown gum (*Eucalyptus dealbata*), western New England blackbutt (*Eucalyptus andrewsii*), Caley's ironbark (*Eucalyptus caleyi*), red stringybark (*Eucalyptus macrorhynca*), McKie's stringybark (*Eucalyptus mckiena*), white cypress pine (*Callitris glaucophylla*) and black cypress pine, rough-barked apple and silver-leaved ironbark (*Eucalyptus melanophloia nophloia*).

Areas at higher altitudes comprise vegetation communities dominated by messmate (*Eucalyptus obliqua*) and mountain gum (*Eucalyptus dalrympleana ssp. heptantha*), with snow gum, black sallee (*Eucalyptus stellulata*) and ribbon gum (*Eucalyptus nobilis*). Orange gum (*Eucalyptus prava*) and black cypress pine are widespread in rocky outcrops in the north of the bioregion. Protected high rainfall areas near the Great Escarpment display cool temperate rainforest elements, including Beech (*Notofagus moorei*) forests. River oak (*Casuarina cunninghamiana*) lines rivers and streams in the western part of the bioregion below an elevation of 800 m, with sedgelands found in some of the smaller streams.

Vegetation found on basalt-derived soil consists of open forests and woodlands of manna gum, snow gum and black sallee. Cold-air drainage inverts the tree patterns in wide valleys, as the distribution of these species is largely determined by climate parameters. Vegetation communities growing on basaltic soils consist of New England stringybark (*Eucalyptus calignosa*) New England blackbutt (*Eucalyptus campanulata*), and narrow-leaved peppermint (*Eucalyptus radiata*) on the hills, with yellow box, wattle-leaved peppermint (*Eucalyptus acaciiformis*), New England peppermint (*Eucalyptus nova-anglica*), snow gum, black sallee and ribbon gum in the valleys.

Open forest of New England stringybark, yellow box, Blakely's red gum and rough-barked apple occurs on Tertiary sands.

Vegetation growing on soils derived from Permian sedimentary rocks in the west is dominated by white box (*Eucalyptus albens*), grey box (*Eucalyptus moluccana*), yellow box and Blakely's red gum, with localised occurrences of mugga (*Eucalyptus sideroxylon*) on stony ridges. Youman's stringybark, tumble down gum and black cypress pine also occur on sediments with silver-leaved ironbark, white cypress pine and the occasional kurrajong. Snow gum and black sallee dominate the coldest ridges while ribbon gum, mountain gum, silver-top stringybark, New England blackbutt and narrow-leaved peppermint dominate moist areas on higher ground. New England stringybark, ribbon gum, and cool temperate rainforest elements are found in moist, sheltered gullies.

7.2 Significant flora

The New England Tableland Bioregion is botanically significant due to its high plant species diversity and high level of endemism. For instance, more than 70 species of Eucalyptus occur on the tablelands, about a third of which are endemic or near endemic to the bioregion. The New England Tableland Bioregion provides habitat for 68 species listed in the schedules of the TSC Act. Thirty of these species are listed as endangered, 39 are listed as vulnerable and one species, *Euphrasia arguta*, is considered extinct in the bioregion (NSW NPWS 2001).

Several of these species are also endemic to the bioregion. These include *Micromyrtus grandis* and *Pimelea venosa*. *M. grandis* has been recorded in the Severn River National Park growing in low exposed heath and woodland. It is also listed as endangered on Schedule 1 of the Commonwealth Endangered Species Protection Act 1992. *P. venosa* is also listed under the NSW TSC Act 1995, and has been recorded in granite country from Deepwater to Tenterfield in the north of the bioregion, but has not been found in recent years.

7.3 Significant fauna

The New England Tableland Bioregion, like the Nandewar Bioregion, supports a considerable proportion of the endangered regent honeyeater (*Xanthomyza phrygia*) population in woodland fragments. Numbers of grassland and ground-feeding insectivorous birds have declined in the bioregion, as have some temperate woodland and forest species, mainly due to changes caused by agriculture (eg. land clearing and habitat fragmentation), a trend which is likely to continue and has occurred across temperate Australia (Australian Terrestrial Biodiversity Assessment 2002).

Ninety-two fauna species listed in the schedules of the TSC Act have been recorded in the New England Tablelands Bioregion (NSW NPWS 2001). Of these, 18 are listed as endangered, 72 are listed as vulnerable and a number of species are considered extinct in the bioregion. This includes the recent extinctions of 2 frog species, *Litoria castanea* and *Litoria piperata*.

7.4 Significant wetlands

Little Llangothlin Lagoon is at the headwaters of the Oban River and much of the lagoon's catchment is within Little Llangothlin Nature Reserve. The lagoon is considered to be in good condition, although incurring pollution from nearby agricultural lands (Australian Terrestrial Biodiversity Assessment 2002), and supports many waterbirds including ducks, ibis, egrets and even the white-breasted sea eagle (*Haliaeetus leucogaster*) along with vulnerable and rare species including the comb-crested jacana (*Irediparra gallinacea*) and the blue-billed duck (*Oxyura australis*) in times of drought (ANCA 1996).

The New England wetlands are representative of shallow, temporary upland lagoons and are considered to be in good condition, despite urban development at nearby Mother of Ducks lagoon. They have a fluctuating water regime, which is important for ecosystem function, and sometimes support the rare stonewort (Charophyte), *Nitella hookeri*. The wetlands also provide important habitat for migratory birds and include parts of Little Llangothlin, Mother of Ducks and Dangars Lagoon Nature Reserve. Upland wetlands of the New England Tableland are now listed under the TSC Act as an endangered ecological community.

Round Mountain is in Cathedral Rock National Park and is a representative example of an upland swamp in the New England Tablelands. The swamp is dominated by sedge and like the other wetlands in this bioregion suffers from feral animals and exotic weeds, including blackberry (*Rubus* sp.).

8. Regional history

8.1 Aboriginal occupation

The Aboriginal language groups whose traditional lands lie in the New England Tablelands Bioregion include the Anaiwan (the area around Armidale) and the Kwaimbul in the north, while the Banbai inhabited areas around Ben Lomond and Mt Mitchell at the centre of the region. Bundjalung people also inhabited the north-eastern side and Ngarrabul people were located from Glencoe, north to Bolivia then slightly east to the Bundjalung border and west to take in the Beardy plains and the top of the Seven River area. The area around Kingsplains, Wellingrove and Strathbogie stations have also been home to the Ngarrabul.

Aboriginal people used the landscape as both a natural and cultural resource and there is a strong oral history indicating seasonal movement of Aboriginal people through the rugged gorge system, between the coastal plains and tablelands. The tablelands were occupied during summer and autumn, communities moving either to the coast or the western river systems for winter.

Archaeological evidence suggests the tableland Aborigines traded with groups on the Western slopes and that a range of stone tools such as jagged spears, boomerangs and waddies were developed with local and traded stone and local hardwood. Mammals such as kangaroo and possum were used for food, clothing and decoration. The region is also known for ornately carved trees, ceremonial bora grounds and art sites, indicating an intimate spiritual, as well as a physical, attachment to the sacred landscape the Aboriginal people inhabited.

Aboriginal people of the New England Tablelands worked as stockman on stations such as Strathbogie, Wellingrove and Kingsplains. Generally, they had a good relationship with most station managers and the women were engaged in domestic duties.

8.2 European occupation

John Oxley first visited the New England Tablelands Bioregion in 1818 during his early explorations of northern NSW. Squatters began to occupy the area in the 1830s, seeking suitable land for grazing (NSW NPWS 1991). Robert McKenzie occupied the land in the bioregion's north in 1839, where the township of Tenterfield now stands (NSW NPWS 1991), while Glen Innes had similar beginnings as a 25,000-acre station which was acquired by Major Innes of Port Macquarie in 1844. The station at Tenterfield was surveyed in 1851 and incorporated as a municipality in 1872. The railway reached Glen Innes in 1884 and Tenterfield in 1886 (NSW NPWS 1991).

Armidale had a population of only 76 in 1846, but even so it was already serviced by a post office, court house, flour mill, church and several inns. Five years later the population had reached more than 500 and became the central administrative town of the bioregion (HO and DUAP 1996). By 1861 the population of Armidale was 4,200 people and the town grew substantially over the next 40 years, becoming an established centre for education and strengthening its position as a regional capital by the 1890s.

Gold was discovered at Rocky River just southwest of Armidale in 1851 and soon 3,400 miners were there searching for the precious ore. By 1855 this number had grown to 5,000 people. Another goldfield northeast of Glen Innes, with a population of 400 miners including many Chinese settlers, was active throughout the 1850s (HO and DUAP 1996). Further gold and other metals were discovered in the bioregion in the 1870s, 80s and 90s. Tin deposits found at Elsmore in 1871 and Emmaville in 1872 prompted commercial developments and stimulated townships based on eager miners

in their hundreds (NSW NPWS 1991). Tin was discovered throughout the bioregion, advancing towns like Glen Innes and swelling the populations of smaller towns such as Tingha (meaning "the flat place" in the local Aboriginal language) that was largely abandoned after 1900 (HO and DUAP 1996).

Towns like Walcha, Armidale and the nearby Hillgrove gained economic boosts from finds of gold and antimony, while gold and tin mining also occurred in the far north of the bioregion on the upper reaches of the Clarence River (HO and DUAP 1996). The area near what is now Bald Rock Nature Reserve (dedicated in 1906) on the Qld border was declared the Boorook and Lunatic goldfield in 1872 (NSW NPWS 1991). Tenterfield received a boost from the discovery of gold, silver and copper at nearby fields in the adjacent North Coast Bioregion in the 1880s. Bismuth, molybdenite, manganese and sapphires were all mined in the region, with gemstone mining developing only in the 1920s and expanding into the 1960s (NSW NPWS 1991). Many mining relics still remain in the bioregion today, such as the boilers used in quartz crushing that were found in Boonoo Boonoo National Park north of Tenterfield (NSW NPWS 1991).

Cattle grazing was the dominant land use of the bioregion in the early days of European settlement but by the end of the 1800s sheep grazing was expanded due to improved pastures and better fencing (NSW NPWS 1991). The government established an experimental farm at Glen Innes in 1902.

As in the Nandewar Bioregion, softwood timber was abundant but difficult to retrieve. Many forests were dedicated as state forests around 1900 and most are still managed by State Forests of NSW (NSW NPWS 1991).

9. Bioregional-scale conservation

About 220,481.15 ha or 7.7% of the New England Tablelands Bioregion is managed as conservation tenures.

The system of national parks and nature reserves is the major contributor in terms of area and security of protection. National parks and nature reserves (NPW Act 1974) occupy the largest proportion of this area, managing a total area of 182,049.64 ha, or about 6.36% of the bioregion. Approximately 50,927.48 ha of the area of national parks and nature reserves is also wilderness (Wilderness Act 1987), and occupies about 1.78% of the bioregion. Other lands managed under the provisions of the NPW Act 1974 comprise the Stonewoman Aboriginal Area, occupying 1.88 ha or 0.0001% of the bioregion, and the Torrington State Recreation Area which occupies 29,530.78 ha or 1.03% of the bioregion. Reserves also being managed by the National Parks and Wildlife Service under the Crown Lands Act 1989 occupy 219.44 ha or 0.01% of the bioregion.

Some landholders in the bioregion have entered into private land conservation arrangements under the provisions of the NPW Act 1974. These include 7 properties managed by covenants under the voluntary conservation agreement program (occupying about 597 ha or 0.02% of the bioregion) and 8 properties with wildlife refuges comprising an area of 6,239.96 ha or 0.22% of the bioregion.

Landholders on 16 properties also hold property agreements under the provisions of the NVC Act 1997. The conservation zones of these occupy about 1,046.91 ha or 0.04% of the bioregion.

There are 4 flora reserves (Forestry Act 1916) contributing particularly towards flora conservation in the bioregion. These occupy about 795 ha or 0.03% of the bioregion.

State forests (under the provisions of the Forestry Act 1916) occur in the bioregion. Each has various degrees of zoning from commercial forestry to conservation. They occupy about 136,064.91 ha or 4.76% of the bioregion.

The only Indigenous Protected Area in NSW (under the Indigenous Protected Area Program, Environment Australia) is located in the bioregion and occupies 480 ha or 0.02% of the bioregion.

Photo: NPWS

10. Subregions of the New England Tableland Bioregion

(Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Bundarra Downs	Lower Carboniferous mudstones, lithic sandstones and conglomerates.	Upper catchment of the Gwydir River undulating to low hilly country with dendritic drainage pattern. Hills rise to the east on granite metamorphic contact ridges.	Harsh texture contrast soils, generally yellow, thinner and stonier on steep slopes. Some areas of slightly saline soils.	In the west: white box, grey box, yellow box and Blakely's red gum with mugga on stony ridges and river red gum along streams. In the east: broad-leaved stringybark, Youman's stringybark, tumble down gum, white box, yellow box, black cypress pine and kurrajong.
Beardy River Hills	Fine grained Permo-Carboniferous sedimentary rocks with little distortion	Rocky hills and steep gorge of the Beardy River.	Thin stony soils on most slopes. Yellow, harsh texture contrast soils where better developed.	White box, tumble down gum, Caley's ironbark, mugga, Youman's stringybark, and some yellow box. Silver-leaved ironbark with white cypress pine and occasional kurrajong in gorge country.
Walcha Plateau	Faulted inliers of Devonian and Carboniferous sandstone, conglomerate, minor limestone, slate, schist, amphibolite and volcanics. Small stock of granodiorite and central peak and ridge top fingers of Tertiary basalt.	Eastern and southern margin is the Great Escarpment. High central plateau capped by basalts. General topography undulating with small rugged areas often related to geology.	Mellow and harsh texture contrast soils on sediments and granite. Red brown to black structured loams on basalt, thin in places and often stony.	Snow gum and black sallee on coldest wet ridges. Ribbon gum, mountain gum, silver-top stringybark, New England blackbutt, narrow-leaved peppermint, in moist high areas. New England stringybark, ribbon gum, and cool temperate rainforest elements in moist sheltered gullies.
Armidale Plateau	Fine grained Permo-Carboniferous sedimentary rocks, granites and multiple Tertiary basalt flows.	Undulating to hilly plateau at 1100 m. Stepped landscape across basalt flows, broad valleys, steepening to the east at the head of Great Escarpment gorges.	Texture contrast soils on sedimentary rocks and granite, mellow (soft and friable) and well drained on upper slopes, harsh and poorly drained on lower slopes. Variable stony loams to deep black earths in valley floors on basalt. Deep, dark loamy alluvium in swampy valleys.	Open ribbon gum forest and woodland with snow gum and black sallee on basalt. Cold air drainage influence inverts the tree patterns in wide valleys. Yellow box, Blakely's red gum, rough-barked apple, apple box on sedimentary rocks. Silver-top stringybark, New England stringybark on dry aspects, Blakely's red gum, yellow box and apple box on moist, well-drained slopes, and New England peppermint with ribbon gum on flats.
Wongwibinda Plateau	Fine grained Permian sedimentary rocks with small areas of granite and basalt.	Hilly plateau 900-1500 m. Rainfall and temperature decrease to the west. Stepped slopes on basalt. Streams run to steep gorges on the edge of the great Escarpment.	Red and yellow, mellow, texture contrast soils on sedimentary rocks and granites. Shallow stony loams on steep areas of basalt with deep, dark loams on flatter slopes.	Highest areas on basalt; snow gum, black sallee and ribbon gum woodland. Western areas; New England stringybark, narrow-leaved peppermint on hills, yellow box, wattle-leaved peppermint and New England peppermint with snow gum, black sallee and ribbon gum in valleys. Eastern areas above gorges; New England blackbutt, New England stringybark, silver-top stringybark, ribbon gum, narrow-leaved peppermint, yellow box, snow gum and black sallee.

10. Subregions of the New England Tableland Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Deepwater Downs	Permian diorite, acid volcanics and small areas of shales.	Hilly to undulating with broad valleys, elevation 950 m.	Harsh red and yellow texture contrast soils with thin gritty topsoils.	Woodland of Blakely's red gum, apple box, New England stringybark, narrow-leaved peppermint, New England peppermint, rough-barked apple and bull oak.
Glen Innes-Guyra Basalts	Extensive Tertiary basalt flows. Small enclosed areas of granite and fine grained Permian sedimentary rocks. Quaternary sediments in swamps and lagoons.	Stepped plateau from 700-1500 m. Undulating to low hilly. Swamps and lagoons with evidence of past higher water levels and lunettes. Wide valleys in an evolving drainage system.	Deep red brown and brown to black, fertile and well structured loams on basalt. Thinner and stony on steep slopes, waterlogged in valley floors. Harsh, yellow texture contrast soils on granites and minor sedimentary rocks.	High areas have woodland of snow gum, black sallee and ribbon gum. Silver-top stringybark, New England peppermint at lower levels on basalt. White box woodland with rough-barked apple, ribbon gum and yellow box in lowest western areas. Narrow-leaved ironbark on sedimentary rocks.
Ebor Basalts	Tertiary basalt with minor trachyte.	Hilly benched plateau 1200-1500 m. Highest and steepest above the Great Escarpment with 2000 mm rainfall.	Deep, brown well structured loams with high organic content. Stony profiles on trachyte. Waterlogged clayey peats in some valleys. -	Snow gum, black sallee woodland with - New England peppermint, messmate, ribbon gum, shining gum, and brown - barrel. Sphagnum peats in high valleys, - Barren Mountain mallee heaths on - siliceous soils. -
Moredun Volcanics	Lower Permian acid volcanics with minor granite and Tertiary basalts.	Undulating plateau at 1100 m with steep western slope and rugged hills falling to 850 m.	Harsh yellow texture contrast soils with stony brown loams on basalts.	Open forest and woodland of snow gum, black sallee, New England stringybark, McKie's stringybark, silver-top stringybark, ribbon gum, yellow box, and some black cypress pine on the plateau. Mugga, Caley's ironbark, tumbledown gum, white box, yellow box and Youman's stringybark on western slopes.
Severn River Volcanics	Permian mixed volcanics and fine sedimentary rock. Granite intrusions and ridge top patches of Tertiary basalt with underlying sand and gravel.	Undulating to hilly and rugged, elevation range 600 -1200 m. Well developed dendritic drainage with rocky gorges. Rock outcrop common on steep slopes.	Shallow stony sandy loams on steep slopes, harsh texture contrast soils with gritty topsoils common, structured brown loams on small areas of basalt. Some evidence of salinity.	Low western slopes; woodland or heath of orange gum, Caley's ironbark, tumbledown gum, and black cypress pine. Woodlands and forest of red stringybark, western New England blackbutt, narrow-leaved ironbark, white box, yellow box and rough-barked apple. Highest eastern slopes; open forest of New England stringybark, Tenterfield wollybutt, yellow box, narrow-leaved ironbark, apple box, Blakely's red gum with orange gum in rocky outcrops.

10. Subregions of the New England Tableland Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Northeast Forest Lands	Permian fine grained sedimentary rocks, and large areas of granite.	Hilly plateau 950-1500 m. Swampy valleys on some granites.	Deep siliceous sands merging to poorly developed harsh texture contrast soils and areas of red sandy loams to structured sandy clay loams. Most soils prone to surface wash and gully erosion.	Open forest of New England blackbutt, diehard stringybark, Youman's stringybark and messmate. Snow gum and black sallee in cold air pockets, patches of rainforest with Deane's gum in sheltered gullies. White ash adjacent to rock domes, New England mallee and heath on rocky outcrops of Gibraltar Range with wet heath and sphagnum bogs in valleys.
Tenterfield Plateau	Wide range of Permian granites and areas of acid volcanics.	Undulating to hilly variable plateau 500 - 1200 m.	Shallow gritty sands on steep slopes to harsh texture contrast soils. Some evidence of salinity.	Bolivia Range; open forest of New England stringybark with yellow box, rough-barked apple, apple box, kurrajong, black cypress pine and mugga. Considerable local variation with aspect. Remainder of area; woodland of New England peppermint, New England stringybark, Blakely's red gum, yellow box, apple box, rough-barked apple, broad-leaved apple, fuzzy box and bull oak.
Yarrowyck-Kentucky Downs	Permian granites.	Undulating to hilly, general slope northwest 750-1100 m. Areas of rocky outcrop and granite tors.	Mellow texture contrast soils on drained slopes, harsh texture contrast soils on lower slopes. Coarse sandy topsoils prone to erosion and some evidence of salinity in subsoils.	Woodland of Blakely's red gum, New England peppermint, yellow box, rough-barked apple, New England stringybark. Tumbledown gum and black cypress pine on rocky hills. River oak along main streams.
Binghi Plateau	Permo-Carboniferous shales, slates quartzites, and widespread granites.	Rugged rounded hills and valleys. 700-1200 m. Streams more deeply incised at lower levels.	Shallow gritty soils amongst rock outcrop and patches of harsh yellow texture contrast soils on lower slopes and valley floors.	Woodland to open forest of tumbledown gum, New England stringybark, Youman's stringybark, western New England blackbutt, yellow box, apple box, Blakely's red gum, black cypress pine and widespread orange gum.
Stanthorpe Plateau	Fine grained carboniferous sediments and granites.	Low hills to mountains across the Great Dividing Range, elevation from 600-1200 m. Large areas of rock outcrop and granite tors.	Shallow loams and siliceous sands in steep rocky areas, yellow to grey, mellow texture contrast soils on slopes and valley floors.	Complex mixtures of tumbledown gum, Blakely's red gum, western New England blackbutt, New England stringybark, forest red gum, fuzzy box, Caley's ironbark, with angophora, ribbon gum and yellow box. Patches of low rainforest elements on sheltered slopes and limited sedgelands in valleys.

10. Subregions of the New England Tableland Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Eastern Nandewars	Several intrusions of granites each of slightly different composition.	Western edge of the tablelands sloping down to merge with the North West Slopes. 500-1100 m. Hilly with broad valleys and rugged granite outcrops with tors.	Siliceous sands amongst rock outcrops. Widespread mellow texture contrast soils of relatively low fertility and poor structure, prone to erosion.	Open forest and woodland of silver-top stringybark, Blakely's red gum, Youman's stringybark, yellow box, apple box, rough-barked apple with black cypress pine, ribbon gum and some snow gum. Western slopes; tumbledown gum, western New England blackbutt, Caley's ironbark, white cypress pine and black cypress pine, rough-barked apple and silver-leaved ironbark.
Tingha Plateau	Granites with some fine sedimentary rocks and large areas of Tertiary sands and gravels with remnant patches of basalt.	Undulating plateau at 850 m. Steeper western and southern edge to 650 m. Creek lines and lower slopes very disturbed by mining, extensive gully erosion.	Siliceous sands, red earths and mellow texture contrast soils.	Open forest of New England stringybark, yellow box, Blakely's red gum, and rough-barked apple on Tertiary sands. Open forest of red stringybark, McKie's stringybark, silver-top stringybark, mugga, Caley's ironbark and black cypress pine elsewhere.
Nightcap	Permian granites.	Plateau with undulating hills at 1100-1450 m. Broad gentle valleys, massive rock outcrop in some areas.	Sandy yellow and grey, mellow texture contrast soils. Increased organic matter in swampy sedgelands in valleys.	Open forest of narrow-leaved peppermint, New England stringybark, messmate, ribbon gum, snow gum and black sallee. New England mallee on rock outcrops. Sedgeland in some stream lines.
Round Mountain	Permian granites and minor Tertiary basalt.	Plateau with low hills at 1050-1500 m. Broad swampy valleys.	Mellow yellow texture contrast soils overall, small areas of red loams on basalt.	New England stringybark shrubby open forest with western New England blackbutt, wattle-leaved peppermint, narrow-leaved peppermint, and mountain gum. Messmate and ribbon gum with cool temperate rainforest elements and some snow gum Sedgelands in swampy valleys.

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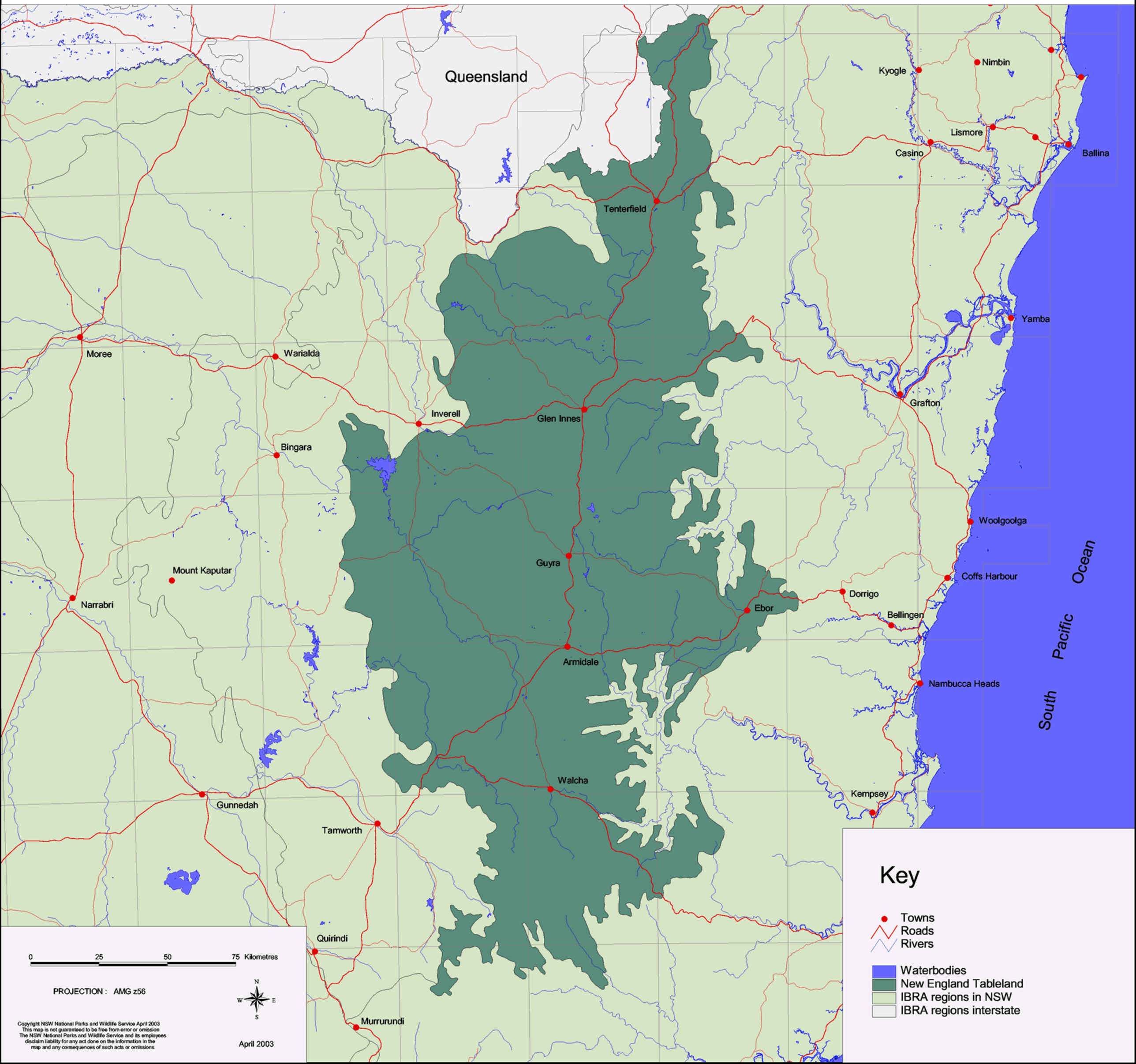
New England Tableland Biogeographic Region (IBRA) - Location



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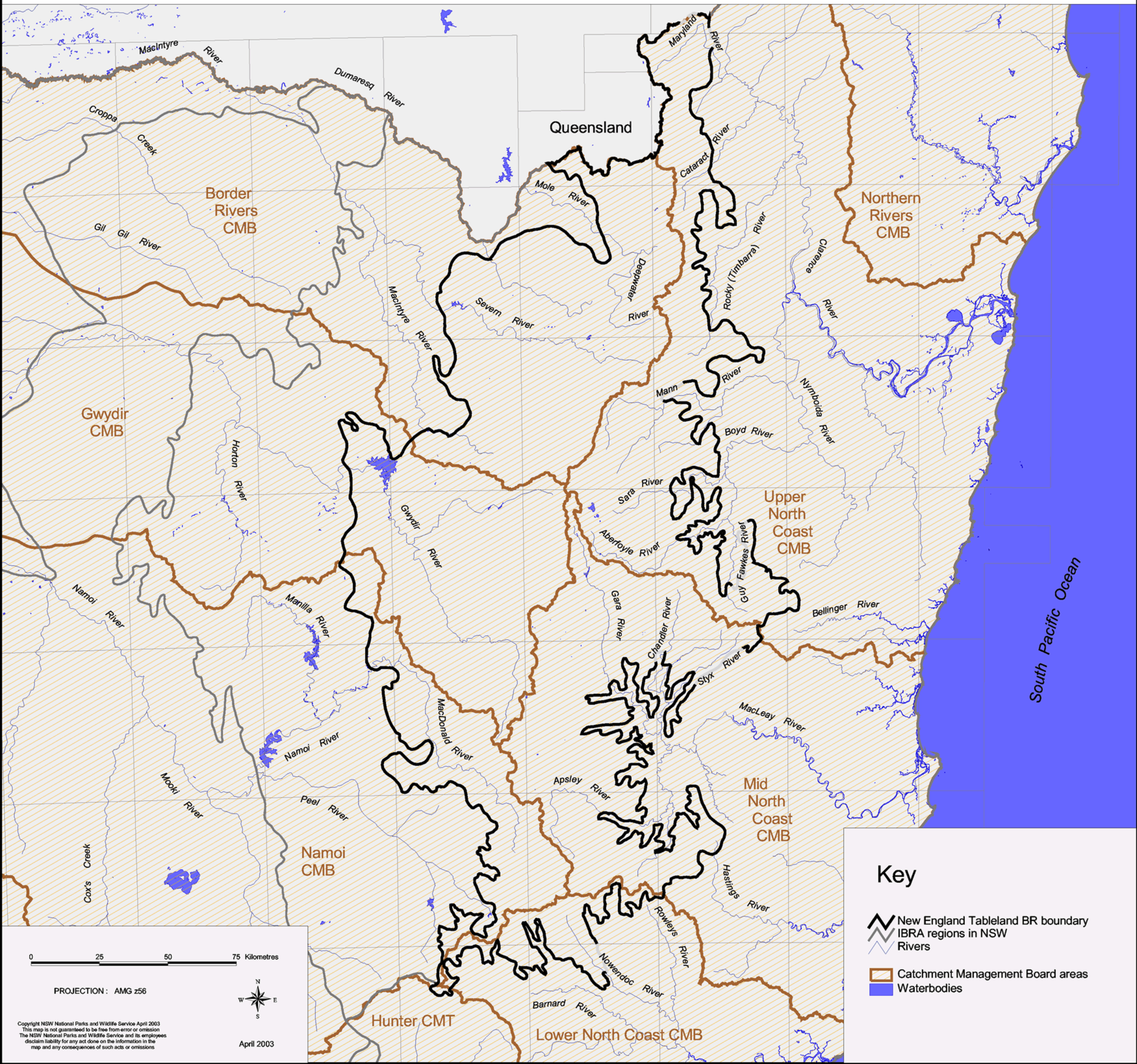


0 25 50 75 Kilometres

PROJECTION : AMG z56

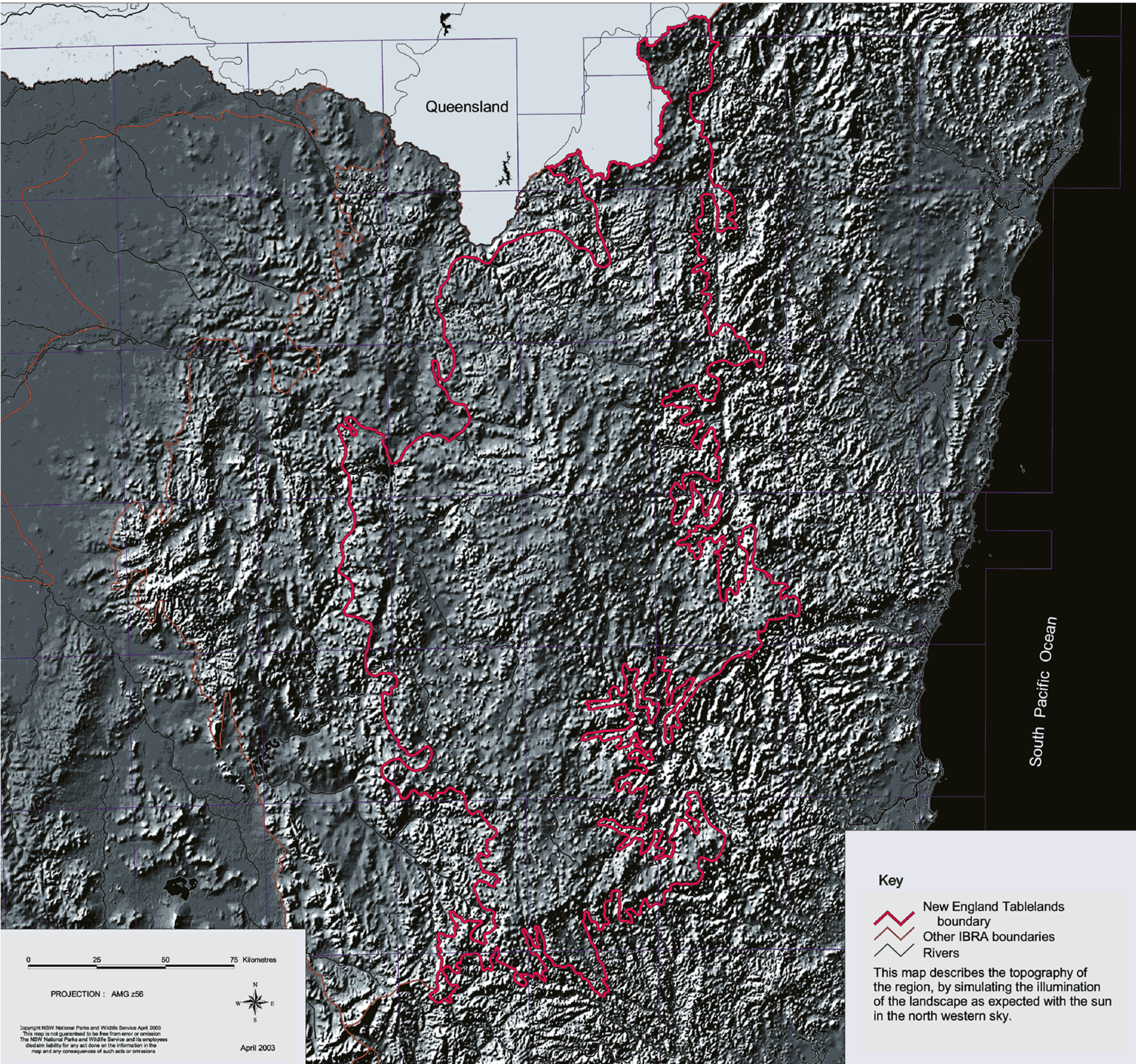
N W E S

April 2003

Key

- New England Tableland BR boundary
- IBRA regions in NSW
- Rivers
- Catchment Management Board areas
- Waterbodies

New England Tableland Biogeographic Region (IBRA) - Topography



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PROJECTION : AMG z56

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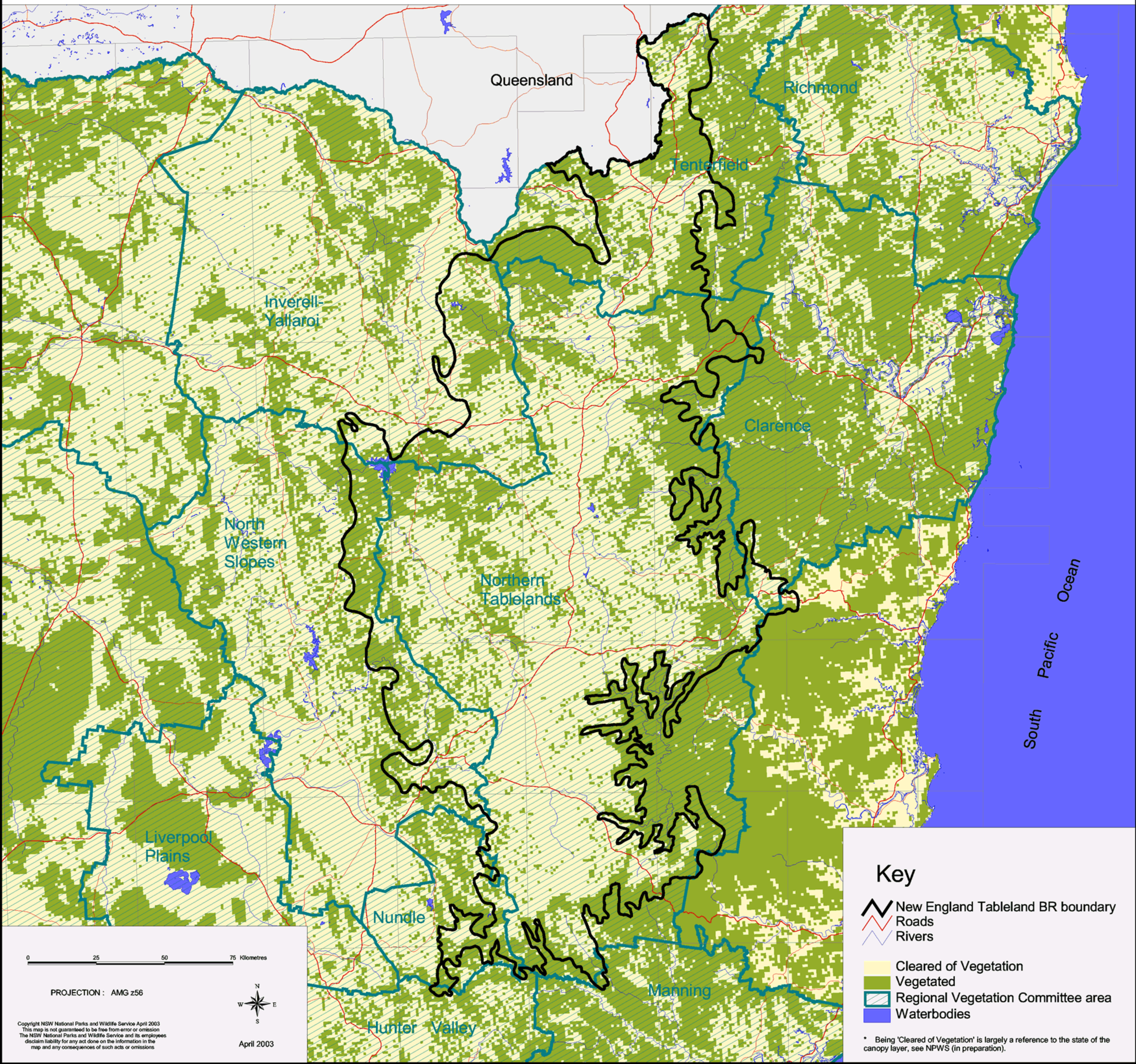
April 2003

Key

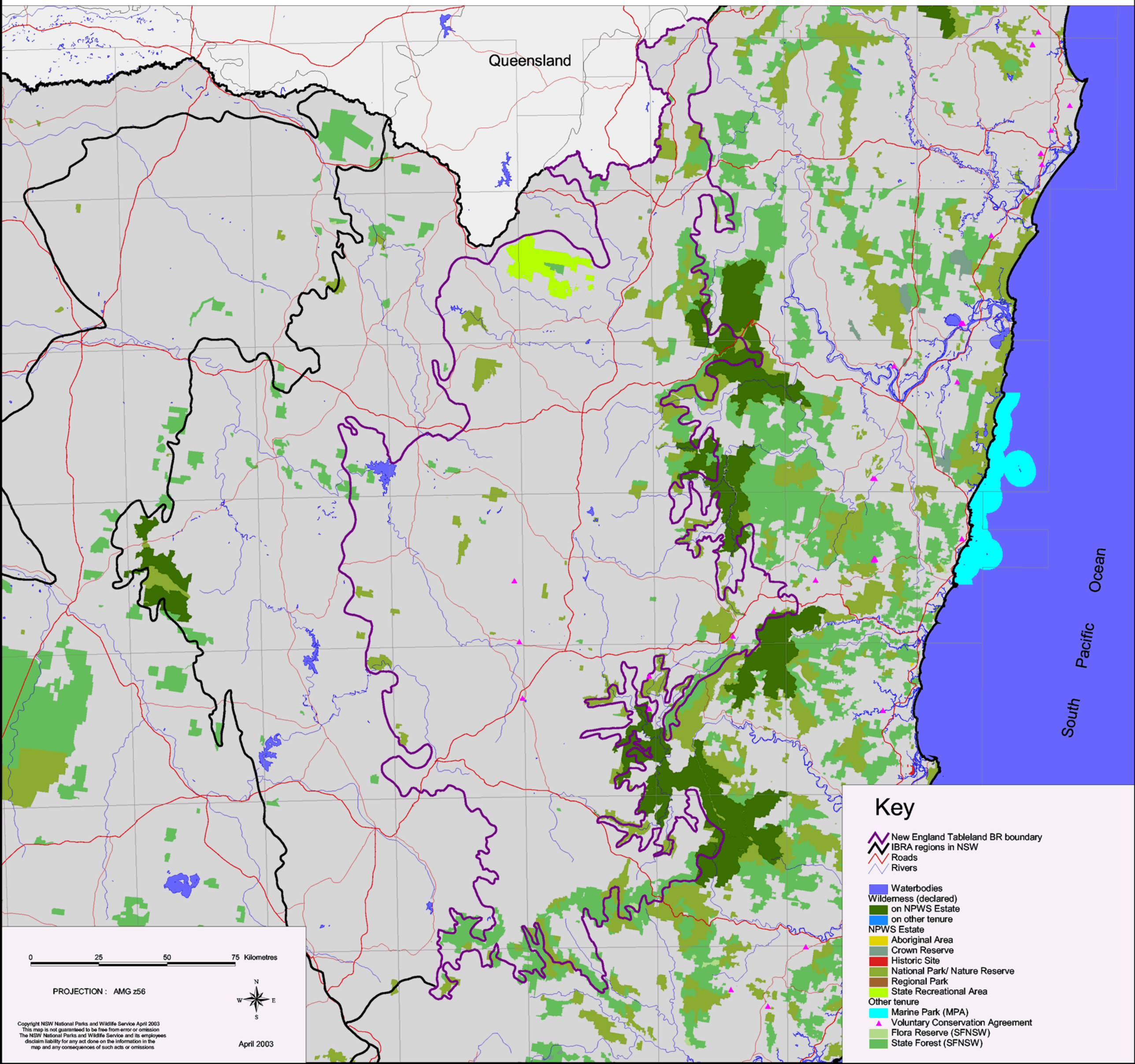
New England Tablelands boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

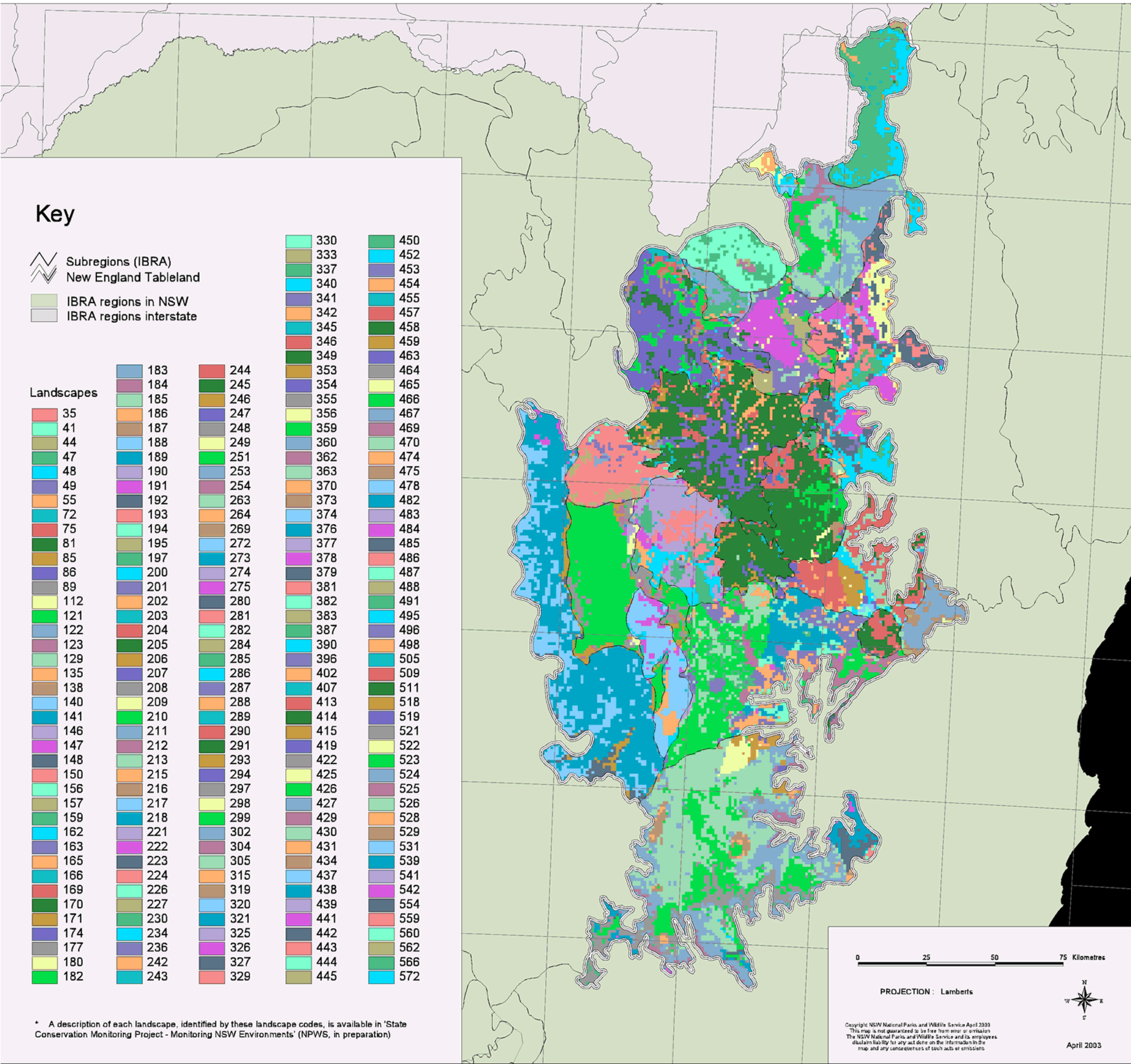
New England Tableland Biogeographic Region (IBRA) - Vegetation



New England Tableland Biogeographic Region (IBRA) - Tenure/Reserves



New England Tableland Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)



CHAPTER 14

The North Coast Bioregion

1. Location

The North Coast Bioregion runs up the east coast of NSW from just north of Newcastle to just inside the Qld border. The total area of the bioregion is 5,924,130 ha (IBRA 5.1) and the NSW portion is 5,692,351.6 ha or 96.1% of the bioregion. The NSW portion of North Coast Bioregion occupies 7.11% of the state.

The Sydney Basin Bioregion bounds the North Coast Bioregion in the south and the Nandewar and New England Tablelands bioregions lie against its western boundary. The North Coast Bioregion has proven to be a popular place to live, with hundreds of "holiday towns" lining the coast and eastern inland, including Port Macquarie, Ballina, Coffs Harbour, Byron Bay, Tweed Heads, Lismore, Alstonville, Dorrigo, Forster and Taree.

The Tweed, Richmond, Clarence, Coffs Harbour, Bellinger, Nambucca, Macleay, Hastings and Manning River catchments all fall in the North Coast Bioregion.

2. Climate

The general trend in this bioregion from east to west is from a sub-tropical climate on the coast with hot summers, through sub-humid climate on the slopes to a temperate climate in the uplands in the western part of the bioregion, characterised by warm summers and no dry season. A montane climate occurs in a small area in the southwest of the bioregion at higher elevations.

3. Topography

The North Coast Bioregion covers northern NSW from the shoreline to the Great Escarpment. Typically, there is a sequence from coastal sand barrier, through low foothills and ranges, to the steep slopes and gorges of the Escarpment itself, with rainfall increasing inland along this transect.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
8 – 20°C	-2.8 – 9.8°C	20.3 – 30.9°C	607 – 2912mm	30 – 99mm	76 – 499mm

4. Geology and geomorphology

The North Coast Bioregion is one of the most diverse in NSW. It has Devonian and Permian bedrocks that are part of the New England Fold Belt and have been closely faulted as they were thrust over the northern margin of the Sydney Basin. Small bodies of granite and granodiorite have intruded the sedimentary rocks and there are three centres of Tertiary basalt eruption.

At the time of the opening of the Tasman Sea by plate movements 80 to 100 million years ago during the break up of Gondwana, the coast of the Australian continent was uplifted and warped. As the ocean widened the uplifted block subsided at the coast and river systems developed that eroded back toward the inland flexure along the warp. Rapid headward erosion of these streams formed the Great Escarpment and cut deep gorges back into the plateau areas of the adjacent New England Tablelands Bioregion. The Great Escarpment is very prominent in this bioregion.

The largest volcanic centre, resulting from Tertiary basalt eruption, is the Tweed volcano and the associated Mt Warning caldera (exploded crater) near the NSW/Qld border. This complex is dated between 20 and 24 million years old, and at the time of eruption was a shield volcano with low slopes that covered an area 80 by 100 km. Mt Warning itself is the remains of a large central feeding chamber, filled with coarser rock than the basalts, rhyolites and tuff on the caldera rim.

The bioregion covers that part of the Late Triassic to Early Cretaceous Clarence-Moreton Basin in NSW. Sediments in this sequence are similar to those in the Sydney Basin and include some minor coal seams. The Clarence-Moreton Basin, however, is in a warmer, wetter environment than most of the Sydney Basin and relatively few plants are common to both environments.

During the cold periods of the Quaternary, the sea level was more than 100 m lower than at present and in the past 18,000 years it has risen to its present position, sweeping sand from the continental shelf before it. This sand has accumulated in the coastal barrier systems that reach their maximum degree of development in the Myall Lakes system, with high foredunes, low inner barrier ridges, wide lake basins and high parabolic dunes blown onto bedrock hills.

5. Geodiversity

Important features include the following:

- the Tweed volcano complex and Mt Warning are one of the best exposed in Australia;
- Ebor Plateau and Comboyne Plateau are central volcanoes about 18 million years old;
- a large number of economic mineral deposits, including extended deposits of heavy minerals in beach and dune sands, most of which have associated heritage items;
- the Great Escarpment is well developed in this bioregion with deep gorges on every major river; and
- areas of serpentinite are evidence of deep-sea sediment accretion on the Australian mainland through time – these rocks also weather to soils with toxic levels of some metals, which affects the vegetation growing on them.

6. Soils

The soil and vegetation patterns in the bioregion are very complex because of the different substrates, the topographic variation and the climatic differences encountered across and along the bioregion. In general, only the most fertile soils (normally from basalts) support rainforests, but exceptions to this are found in numerous protected pockets where plant nutrients have accumulated through organic cycling in litter.

On the basalts the soils are typically red, friable loams or clay loams with high fertility, good structure and excellent water-holding capacity. On granites and most of the quartz rich sedimentary rocks, shallow yellow earths are found on hillcrests, yellow and brown texture contrast profiles are found on the slopes, and organic loams or sandy loams are found on the alluvial plains. In the coastal dunes, deep siliceous sands and very well developed podsols can be found.

7. Biodiversity

7.1 Plant communities

In the north of the bioregion, soils derived from basalts support sub-tropical and warm temperate rainforests, or wet sclerophyll forests. Dominant species include black booyong (*Argyrodendron actinophyllum*), white booyong (*Argyrodendron trifoliolatum*), hoop pine (*Araucaria cunninghamii*), bangalow palm (*Archontophoenix cunninghamiana*), climbing palm (*Calamus muelleri*), rough tree fern (*Cyathea australis*), Australian cedar (*Toona australis*), teak (*Flindersia australis*), white mahogany (*Eucalyptus acmenoides*), small-fruited grey gum (*Eucalyptus propinqua*), tallowwood (*Eucalyptus microcorys*) and

Photo: Mike Williams

Sydney blue gum (*Eucalyptus saligna*). In the south of the bioregion on the Barrington Plateau, cool temperate species are more common, including Antarctic beech (*Nothofagus moorei*), which occurs as a monoculture with a fern understorey. In addition to the fertile areas derived from basalts, rainforests are sometimes found inhabiting protected pockets where plant nutrients have accumulated through organic cycling in litter.

Forests occurring on soils derived from granites are mainly eucalypt vegetation communities. The dominant species include blackbutt (Eucalyptus *pilularis*), Sydney blue gum, spotted gum (*Eucalyptus maculata*), grey gum (*Eucalyptus punctata*), forest red gum (*Eucalyptus tereticornis*), red bloodwood (*Corymbia gummifera*), brush box (*Tristania conferta*) and white mahogany.

In the coastal dunes, the vegetation sequence includes coast tea tree (*Leptospermum laevigatum*) and coastal wattle (*Acacia longifolia*) near the beach, with some areas of beach she-oak (*Casuarina equisetifolia*), snappy gum (*Eucalyptus racemosa*), blackbutt, dwarf red bloodwood and bastard mahogany (*Eucalyptus umbra*). Banksia and bangalow palms are found in the dunes and heath and paperbark swamps occur behind the dunes and near the lagoons. Rare patches of rainforest species can be found even here where sufficient nutrients have accumulated.

Estuaries are dominated by mangrove communities composed of *Avicennia marina, Aegiceras coniculatum, Exoecaria agallocha* and saltmarsh species. Freshwater margins are occupied by swamp oak (*Casuarina glauca*) and paperbark (*Melaleuca quinquenervia*) while flooded gum (*Eucalyptus grandis*) grows on alluvial river flats.

7.2 Significant flora

Two hundred and two flora species found in the North Coast Bioregion are listed in the schedules of the TSC Act. Of these, 108 are endangered, 89 are vulnerable and 5 are considered extinct in the bioregion (NSW NPWS 2001).

Several of these species are endemic to the bioregion, including *Zieria prostrata* and *Elaeocarpus* sp. Rocky Creek. *Z. prostrata* is restricted to Moonee Beach Nature Reserve and is listed as endangered in both State and Commonwealth legislation. *E.* sp Rocky Creek is found in only 4 locations on the southern edge of the Mt Warning caldera and is also listed as endangered in both State and Commonwealth legislation.

7.3 Significant fauna

One hundred and fifty-seven fauna species recorded in the North Coast Bioregion are listed in the schedules of the TSC Act (NSW NPWS 2001). Of these, 36 are listed as endangered and 121 are listed as vulnerable.

The subtropical habitats of the North Coast Bioregion are rich in bird diversity, with many endemic species and species with restricted distributions, especially in rainforest habitats where there are also several threatened species. The bioregion is important for the logrunner (*Orthonyx temminckii*), paradise riflebird (*Ptiloris paradiseus*), the vulnerable Albert's lyrebird (*Menura alberti*), rufous scrub-bird (*Atrichornis rufescens*) (both the northern vulnerable and near-threatened southern subspecies), the critically endangered Coxen's fig-parrot (*Cyclopsitta dipthalma coxeni*) and northern species of eastern bristlebird (*Dasyornis brachypterus*) (Australian Terrestrial Biodiversity Assessment 2002). The only breeding population of Gould's petrel (*Pterodroma leucoptera*) occurs on two small islands off the coast of Newcastle.

Numbers of grassland species and ground-feeding insectivorous birds, as well as temperate woodland and forest birds, appear to have declined in the bioregion. This decline in forest birds is against the national trend (Australian Terrestrial Biodiversity Assessment 2002). The white-headed pigeon (*Columba leucomela*), long-billed corella (*Cacatua tenuirostris*), little corella (*Cacatua sanguinea*), rainbow lorikeet (*Trichoglossus haematodus*) and common myna (*Acridotheres tristis*) have increased in number in the bioregion. The continued loss of woodland birds, particularly those sensitive to fragmentation, is likely, while rainforests species remain stable (Australian Terrestrial Biodiversity Assessment 2002).

7.4 Significant wetlands

Eight significant wetlands have been identified in the North Coast Bioregion (Australian Terrestrial Biodiversity Assessment 2002). Clarrie Hall Dam supports several significant species, including the vulnerable comb-crested jacana (*Irediparra gallinacea*) and the endangered black-necked stork (*Ephippiorhynchus asiaticus*).

The Brunswick River Floodplain supports a number of threatened species including the vulnerable comb-crested black bittern (*Ixobrychus flavicollis*), freckled duck (*Stictonetta naevosa*), mangrove honeyeater (*Lichenostomus fasciogularis*) and the endangered black-necked stork (*Ephippiorhynchus asiaticus*). Threatened flora on this section of floodplain includes the vulnerable bakers wattle (*Acacia bakeri*) and the endangered *Randia moorei*.

Cumbebin Swamp provides habitat for the endangered black-necked stork (*Ephippiorhynchus asiaticus*) and Mitchell's rainforest snail (*Thersites mitchellae*). Other vulnerable species recorded are the bush hen (*Amaurornis olivaceus*), great knot (*Calidris tenuirostris*), grass owl (*Tyto capensis*) and the little bent-wing bat (*Miniopterus australis*).

Cokora Lagoon supports a diversity of wetland birds including the vulnerable brolga (*Grus rubicundus*), pied oystercatcher (*Haematopus longirostris*) and the endangered black-necked stork (*Ephippiorhynchus asiaticus*).

Blue Lake is protected in Yuraygir National Park. This wetland provides habitat for the vulnerable brolga (*Grus rubicundus*), the comb-crested jacana, the endangered black-necked stork and green and golden bell frog (*Litoria aurea*). The endangered little tern (*Sterna albifrons*) has also been recorded at the lake. The little tern is protected under both the JAMBA and CAMBA agreements. Other vulnerable species include the glossy black cockatoo (*Calyptorhynchus lathami*), masked owl (*Tyto novaehollandiae*), rose-crowned fruit dove (*Ptilinopus regina*) and squirrel glider (*Petaurus norfolcensis*).

An unnamed swamp next to Kalang River in the Nambucca catchment has also been identified as one of the most significant wetlands in the bioregion. The vulnerable comb-crested jacana and blue-billed duck (*Oxyura australis*), as well as the endangered black-necked stork, have been recorded at the swamp. Other vulnerable species found here include the glossy black cockatoo (*Calyptorhynchus lathami*), squirrel glider (*Petaurus norfolcensis*) and koala (*Phascolarctos cinereus*) (Australian Terrestrial Biodiversity Assessment 2002).

Lake Innes supports the vulnerable Australasian bittern (*Botaurus poiciloptilus*) and the endangered black-necked stork. Other vulnerable species recorded here include the osprey (*Pandion haliaetus*), grass owl (*Tyto capensis*), koala, greater broad-nosed bat (*Scoteanax rueppellii*) and wallum froglet (*Crinia tinnula*).

Grahamstown Lake provides habitat for the vulnerable blue-billed duck and freckled duck as well as the endangered black-necked stork. There have also been many sightings of the vulnerable koala (*Phascolarctos cinereus*) and the Australian Museum has recorded the vulnerable tiger quoll (*Dasyurus maculatus*) at the lake.

Threats to the wetlands in this bioregion are numerous and include changed drainage patterns from construction of roads, drains and channels, particularly in expanding urban areas. Cudgens Lake in particular is affected by increased flooding because the lake's entrance is permanently open.

Water quality is continually affected by urban and agricultural runoff such as the discharge of treated sewerage into Port Stephens estuary. Minor impacts have resulted from recreational activities such as camping and bushwalking, with more serious impacts, such as damage to coral reefs from boat anchors, caused by recreational and commercial users of the estuaries. Other impacts include the presence of feral animals and exotic weeds, acid sulfate soils, sedimentation, erosion and grazing pressure.

8. Regional history

8.1 Aboriginal occupation

The high diversity and abundance of natural resources available to the Aboriginal people (Berndt and Berndt 1964) of the North Coast Bioregion resulted in a high density of Aboriginal occupation in the bioregion, particularly around the northern rivers close to the coast. The marine environment coupled with the lush vegetation along the coast provided the people with much of what they needed to subsist.

Towards the grassy plains of the bioregion further inland, Aboriginal people were hunter-gatherers, living similar lifestyles to the people of the New England Bioregion and in the west. The coastal and inland groups were linked by trade and all shared a common interest in the landscape, which was closely linked to their spirituality, a factor which was threatened significantly by European settlement (HO and DUAP 1996).

The traditional lands of the Muruwari and Gumbaingirr people are on the mid-North Coast in the bioregion. Despite the hardships they encountered in association with the defence of their homelands during European settlement, they have retained their strong links with the land up to the present time (English and Brown 2000). During European settlement in the mid-nineteenth century, the Muruwari and Gumbaingirr people were subjected to much violence, including bloody massacres. After these clashes, the people were determined to remain on the land and gained pastoral work on farms, or lived in station camps or on vacant crown lands nearby, enabling them to achieve this (English and Brown 2000) while avoiding being moved onto Missions.

8.2 European occupation

John Oxley first explored the bioregion by land around 1818 and was soon followed by early settlers.

A penal settlement, which up until the 1820s was located at Newcastle, was moved to Port Macquarie in 1823. Here, convicts grew maize for their own consumption and also attempted to grow sugar on the Hastings and Wilsons Rivers. The sugar-growing venture was not viable due to frost and floods although its mild success prompted another attempt to be made in the 1860s. Cedar cutters who were initially stationed around the Hunter region followed the convicts north in the 1820s, reaching the Macleay in 1837, the Clarence in 1838 and moving further north to the Richmond River in 1842. Logs transported on the rivers were intercepted at ports downstream before being shipped to Sydney. These ports, including Ballina on the Richmond River and Grafton on the Clarence, were based on the cedar industry and were the first settlements on the rivers of the north coast (HO and DUAP 1996). Around the same time the demand for ships to transport the cedar to Sydney, and the abundant timber sources along the rivers, encouraged the shipbuilders to accompany the cedar industry in its move northward (HO and DUAP 1996).

The Port Macquarie penal settlement was removed in 1833, leaving only a prison until 1846. This enabled the government to open up the land around Port Macquarie to free settlement, prompting the start of the pastoral occupation of the North Coast Bioregion (HO and DUAP 1996).

The early farming settlements of the North Coast Bioregion began in the late 1830s with holdings owned rather than leased by the landholders. These were concentrated on the small areas suitable for grazing. Beyond its beginnings in the 1840s, the expanding pastoral industry formed the basis for several towns such as Casino and Kempsey along the north coast. Much of the land in the bioregion was unsuitable for grazing and so experimental crops were planted and, when successful, harvested. Such crops included wheat, maize, tropical crops such as arrowroot, mangoes, sugarcane, breadfruit and opium poppies, while coffee, tea, tobacco, cotton and rice were also grown experimentally (HO and DUAP 1996). Of these experimental crops, maize and sugarcane were most successful although maize was worth little, often being fed to pigs, and after rapid expansion of the sugarcane industry through the 1860s and 1870s, sugarcane crops were struck by disease in the 1890s, at which point many farmers turned to dairying.

Despite early seasonal problems with dairying, the industry became highly successful towards the turn of the century, gradually expanding from the floodplains in the direction of the beef cattle industry further inland and then to the basaltic plateaus above the river valleys. Dairying began in the north around the Richmond River, but progressed further south with time, remaining successful beyond the 1920s (HO and DUAP 1996). It formed the foundation, complete with butter factories, for many towns of the bioregion, which also relied on maize and sugar farming.

The tourism industry accelerated in the 1960s and is still prolific today. Sand mining is also a relatively new industry in the bioregion. While dairying has withdrawn from the bioregion, the beef cattle industry has continued, and now occupies much of the former dairying land. The discovery of gold, silver and copper at fields in the north west of the bioregion in the 1880s saw the establishment of yet another land use in the bioregion (HO and DUAP 1996).

The bioregion has become a popular target for retirees who, along with younger people, have moved to the area to experience a more relaxed lifestyle than that seen in Sydney. The bioregion is illustrative of an environment that is so complex that it provides a wide diversity of niches, both ecologically and in terms of the land-use potential available within the bioregion (HO and DUAP 1996).

9. Bioregional-scale conservation

The North Coast Bioregion has the second highest area of conservation oriented mechanisms of the NSW bioregions. Together, these tenures occupy about 1,061,709.63 hectares or 18.65% of the bioregion.

National parks and nature reserves (under the NPW Act 1974) make the greatest contribution to the area conserved, occupying a total area of 991,386,82 ha, or about 17.42% of the bioregion. Of this area, about 347,425.61 ha is provided additional management under the Wilderness Act 1987 and is composed of 11 declared wilderness areas, together occupying about 6.1% of the bioregion.

Further recognition and protection is also given to national parks in the bioregion in an area extending from Newcastle to Brisbane, known as the Central Eastern Rainforest Reserves. This has been included on the globally recognised World Heritage list as one of three world heritage areas in NSW. Occupying approximately 307,284 ha or 5.40% of the bioregion, the area is protected by international convention as well as the Commonwealth EPBC Act 1999, which automatically protects all Australian properties that are on the World Heritage List.

Reserves (Crown Lands Act 1989) managed by the National Parks and Wildlife Service contributes 21,862.34 ha to the area managed for biodiversity conservation in the bioregion.

Other lands managed under the NPW Act 1974 include: land managed as Aboriginal area (125.61 ha or 0.002% of the bioregion); land managed as historic site (482.8 ha or 0.008% of the bioregion); and land managed as state recreation areas (222.1 ha or 0.004% of the bioregion).

Within recent years, landholders on 25 properties have entered into voluntary conservation agreements. Together the area managed permanently for conservation management occupies about 1362.53 ha or 0.02% of the bioregion. Landholders on 71 properties also hold wildlife refuges, occupying 36,720.46 ha or 0.65% of the bioregion, making a significant contribution to off-park landscape conservation. Updated mapping is likely to increase the area occupied under wildlife refuges.

Landholders on 120 properties have entered into property agreements (NVC Act 1997). The conservation zones of the agreements occupy about 2,036.93 ha or 0.04% of the bioregion

Outside of the NPW Act 1974, 36 flora reserves under the provisions of the Forestry Act 1916 contribute towards biodiversity conservation in the bioregion, occupying about 7,510.05 ha or 0.13% of the bioregion.

Also under the provisions of the Forestry Act 1916, State forests (managed primarily for forestry activities but each with various degrees of zoning from commercial forestry to conservation), occupy about 789,329.45 ha or 13.87% of the bioregion.

Two State Environmental Planning Policies operate in the North Coast Bioregion. SEPP 14 (Coastal Wetlands) (78,317.08 ha or 1.38%) and SEPP 26 (Littoral Rainforests) (629.74 ha or 0.01% of the bioregion).

Photo: P. Green

10. Subregions of the North Coast Bioregion

(Morgan 2001)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Murwillumbah	Folded Devonian lithic sandstones, slate and phyllite. Small areas of loamy alluvium.	Finely dissected steep ranges, with narrow alluvial plains. Relief to 250 m.	Shallow yellow earths on hill crests, yellow and brown texture contrast profiles on slopes and organic loams on alluvial plains.	Wet and dry sclerophyll forests, including blackbutt, Sydney blue gum, forest red gum on lower slopes and plains.
Richmond-Tweed	Jurassic lithic and quartz sandstones and shales exposed in valleys. Tertiary volcanics of the Mt Warning complex. Mainly sheet basalts, with minor rhyolite and tuffs. Major syenite and gabbro plug – remnant of the caldera explosion.	Dissected volcanic caldera with central plug of Mt Warning. Basement recks exposed around the plug and an outer rim of volcanic flows with well-developed radial drainage pattern. Steep slopes and relief of 1100 m.	Red friable loams on basalts, texture contrast and fabric contrast soils on volcanic rocks on slopes, all with high fertility. Low fertility texture contrast soils on sandstones and shales. Cracking clays in valleys.	Subtropical and warm temperate rainforests and wet sclerophyll forests including; black booyong, white booyong, hoop pine, bangalow palm, climbing palm, rough tree fern, Australian cedar, teak, white mahogany, small-fruited grey gum, tallowwood and Sydney blue gum.
Woodenbong	Jurassic lithic and quartz sandstones, and shales with areas of Tertiary basalts.	Hilly, basalt ridges and plateau remnants. Outer and dissected parts of Mt Warning caldera slopes. Relief to 600 m.	Fertile red earths and red loams on basalt. Poor red, brown and yellow, texture contrast soils on sedimentary rocks. Sands and loams along streams.	Rainforests on basalt as for Richmond-Tweed. Wet and dry sclerophyll, including New England blackbutt, red bloodwood and tallowwood on sedimentary rocks.
Clarence Basin	Sub-horizontal Jurassic and Cretaceous lithic and quartz sandstones and claystones. Extensive areas of alluvials and coastal barrier sands.	Low stepped hills and plains, with hillier areas in west and south. Beach, dune and lagoon barrier systems and estuarine fills along the main streams.	Mellow texture contrast soils and areas of deep sand on Mesozoic rocks. Deep siliceous sands and podsols in dunes, organic sands and mud in estuaries.	Dry sclerophyll forests and woodlands of spotted gum, grey gum, blackbutt, red bloodwood and white mahogany in the hills. Dune sequence includes paperbark, snappy gum, blackbutt, dwarf red bloodwood, bastard mahogany with banksia, bangalow palm and areas of heath and paperbark swamp. Mangroves in estuaries.
Nymboida	Complex faulted bedrock of Devonian slates and quartzites, and Permian mudstones and lithic sandstones both intruded by granodiorites. Areas of Tertiary basalt on the margins of the Great Escarpment. Serpentinite at Baryulgil.	Foothills of the Great Escarpment with steep slopes and high rainfall. Relief to 750 m. Some isolated plateaus often with a basalt cap.	Red earths and red loams on basalts and granodiorites. Red and brown texture contrast soils on volcanics and sedimentary rocks.	Dry sclerophyll forest, including northern grey ironbark, broad-leaved white mahogany, white mahogany, tallowwood and turpentine. Rainforest elements in sheltered locations along escarpment including coachwood, crabapple, prickly ash, and rough tree fern.

10. Subregions of the North Coast Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Manning-Macleay	Extremely complex faulted terrain where the New England Fold belt over-thrusts the Sydney Basin. Main rocks present are: Silurian and Devonian slates, quartzites and acid volcanics, Carboniferous mudstones and lithic sandstones, and less deformed Permian shales and sandstones. Small areas of granite and plateaus of Tertiary basalt on Barrington and Comboyne Plateaus. Quaternary coastal sands.	Complex pattern of ridges and valleys running to the Great Escarpment, strong structural control along fault lines. Coastal beach, dune and lagoon barrier systems reach their maximum development at Myall Lakes.	Red brown structured loams on basalt. A range of other soil types relating to geology but poorly known. Deep siliceous sands and very well developed podsols in dunes, particularly the older high dunes. Organic sands in estuaries.	Wet sclerophyll forest with white mahogany, small-fruited grey gum, Sydney blue gum, blackbutt, tallowwood and brush box. White gum, blackbutt, forest red gum and grey box on dry open flats. Dense Antarctic beech on Barrington tops and patches of mixed cool temperate and warm temperate rainforest on Comboyne Plateau on basalt. Coastal complex of banksia, paperbark, smooth-barked apple, and blackbutt with numerous shrubs and areas of heath and swamp on dunes. Mangroves in estuaries.
Southern Coastal Lowlands	Quaternary alluvial sand, coastal sands. Minor Devonian slate, phyllite and quartzite.	Alluvial plains and coastal beach, dune barrier system and estuary of the Tweed River. Low hills to 25 m.	Siliceous sands and deep podsols in older dunes. Organic sands and muds along the streams and edges of the estuary. Mellow texture contrast soils on bedrock.	Coastal heaths and woodlands on the dunes with paperbark, snappy gum, blackbutt, dwarf red bloodwood, bastard mahogany with banksia, bangalow palm and other shrubs. Areas of seasonally waterlogged heath and swamp. Swamp oak, paperbark and saltmarsh species with mangroves in estuaries. Flooded gum on alluvial flats.

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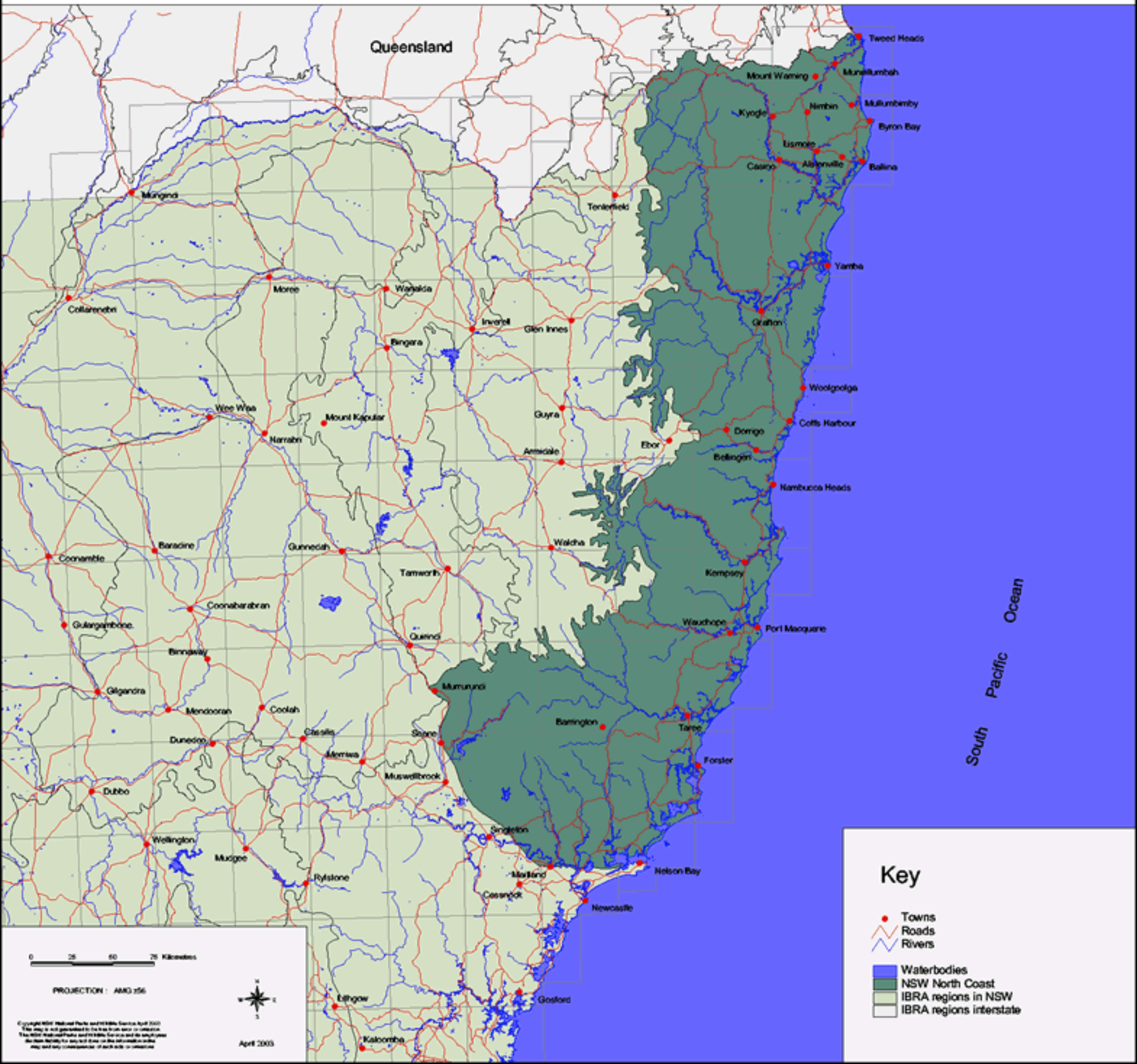
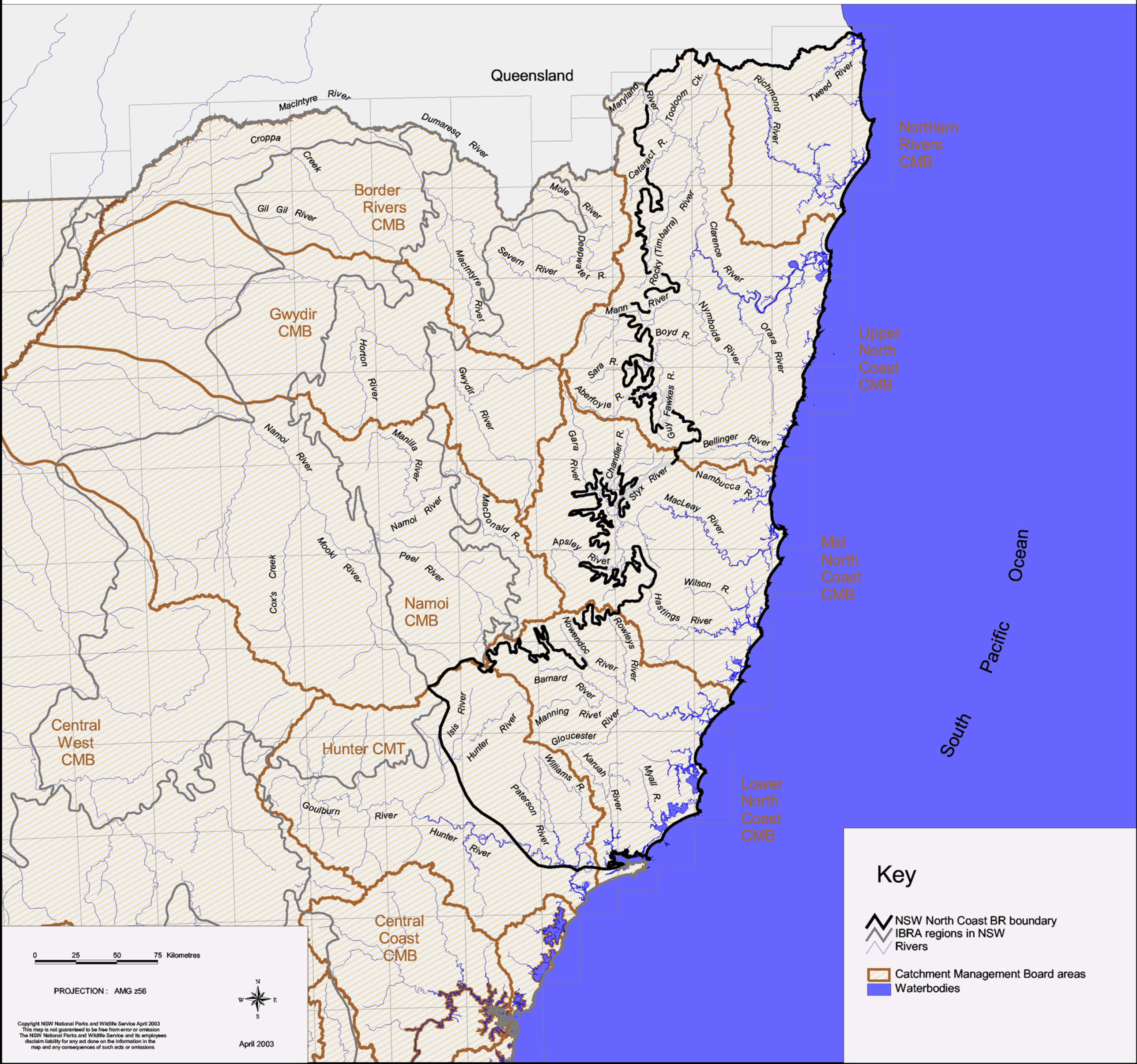
North Coast

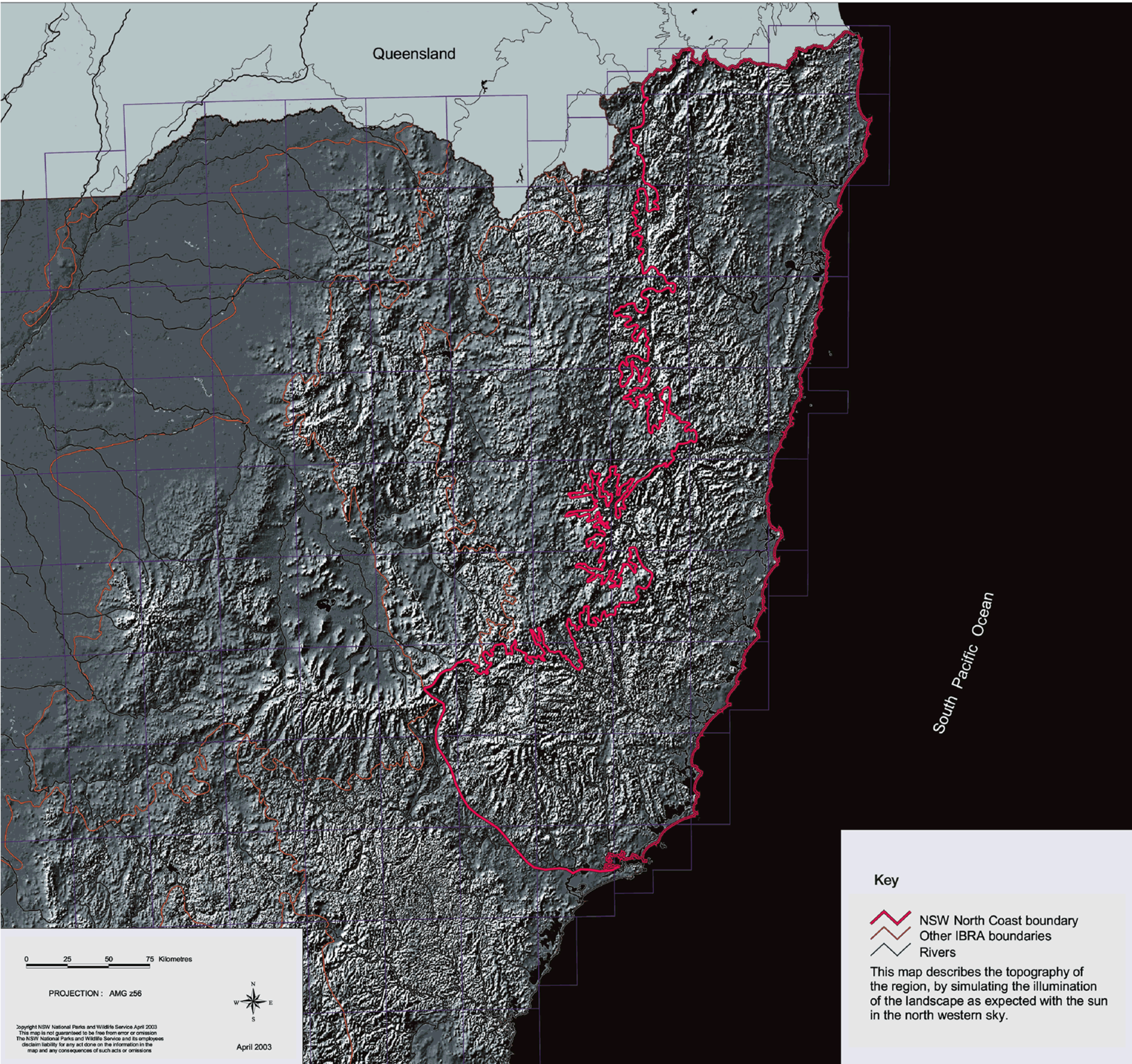
NSW North Coast Biogeographic Region (IBRA) - Location



NSW North Coast Biogeographic Region (IBRA) - Rivers



NSW North Coast Biogeographic Region (IBRA) - Topography



0 25 50 75 Kilometres

PROJECTION : AMG z56

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April 2003

Key

NSW North Coast boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

NSW North Coast Biogeographic Region (IBRA) - Vegetation

NSW North Coast Biogeographic Region (IBRA) - Tenure/Reserves

South Pacific Ocean

Key

- NSW North Coast BR boundary
- IBRA regions in NSW
- Roads
- Rivers
- Waterbodies
- Wilderness (declared)
  - on NPWS Estate
  - on other tenure
- NPWS Estate
  - Aboriginal Area
  - Crown Reserve
  - Historic Site
  - National Park/ Nature Reserve
  - Regional Park
  - State Recreational Area
- Other tenure
  - Marine Park (MPA)
  - Voluntary Conservation Agreement
  - Flora Reserve (SFNSW)
  - State Forest (SFNSW)

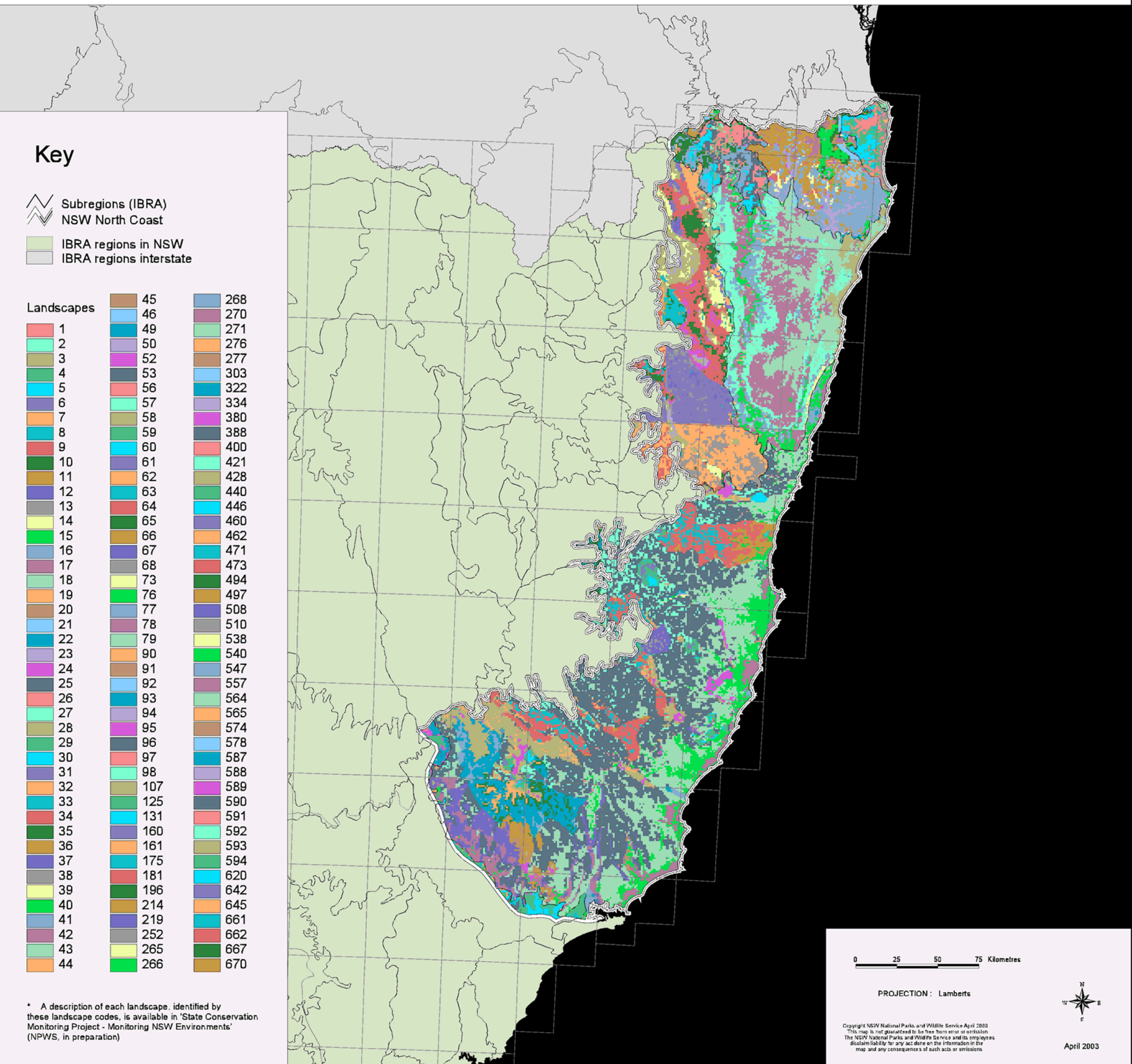
0 25 50 75 Kilometres

PROJECTION : AMG z56

N W E S

April 2003

NSW North Coast Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)



CHAPTER 15

The Sydney Basin Bioregion

1. Location

The Sydney Basin Bioregion lies on the central east coast of NSW and covers an area of approximately 3,624,008 ha (IBRA 5.1). It occupies about 4.53% of NSW and is one of two bioregions contained wholly within the state. The bioregion extends from just north of Batemans Bay to Nelson Bay on the central coast, and almost as far west as Mudgee. The bioregion is bordered to the north by the North Coast and Brigalow Belt South bioregions, to the south by the South East Corner Bioregion and to the west by the South Eastern Highlands and South Western Slopes bioregions.

As well as Sydney itself, the Sydney Basin Bioregion encompasses the towns of Wollongong, Nowra, Newcastle, Cessnock, Muswellbrook and Blue Mountains towns such as Katoomba and Mt Victoria.

It includes a significant proportion of the catchments of the Hawkesbury-Nepean, Hunter and Shoalhaven river systems, all of the smaller catchments of Lake Macquarie, Lake Illawarra, Hacking, Georges and Parramatta Rivers, and smaller portions of the headwaters of the Clyde and Macquarie rivers.

2. Climate

The Sydney Basin Bioregion is dominated by a temperate climate characterised by warm summers with no dry season. A sub-humid climate occurs across significant areas in the northeast of the bioregion. A small area in the west of the bioregion around the Blue Mountains falls in a montane climate zone. Snow can occasionally occur in this area of higher elevation.

Rainfall can occur throughout the year, but varies across the bioregion in relation to altitude and distance from the coast, with wetter areas being closer to the coast or in higher altitudes.

Temperature varies across the bioregion, with areas of higher temperature occurring along the coast and in the Hunter valley and areas of lower temperature on the higher plateaux and western edge.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
10 – 17˚C	-1.4 – 8.1˚C	22.4 – 31.9˚C	522 – 2395mm	26 – 101mm	69 – 245mm

3. Topography

The Sydney Basin Bioregion lies on the east coast and covers a large part of the catchments of the Hawkesbury-Nepean, Hunter and Shoalhaven river systems. It consists of a geological basin filled with near horizontal sandstones and shales of Permian to Triassic age that overlie older basement rocks of the Lachlan Fold Belt. The sedimentary rocks have been subject to uplift with gentle folding and minor faulting during the formation of the Great Dividing Range. Erosion by coastal streams has created a landscape of deep cliffed gorges and remnant plateaus across which an east-west rainfall gradient and differences in soil control the vegetation of eucalypt forests, woodlands and heaths. The Sydney Basin Bioregion includes coastal landscapes of cliffs, beaches and estuaries.

4. Geology and geomorphology

The Sydney-Bowen Basin was formed when the earth's crust expanded, subsided and filled with sediment between the late Carboniferous and Triassic. Early stages of development were as a continental rift that filled with marine volcanic sediments, but deposition shifted to river and swamp environments in a cold climate in the early Permian. Coal deposits accumulated and the upper parts of the basin were covered in quartz sandstone by extremely large braided rivers whose headwaters lay hundreds or even thousands of kilometres away and flowed in from the south and the northwest to deposit the Hawkesbury Sandstone. Shallow marine sediments and later more river sediments continued to accumulate in the basin during the Jurassic but all of these younger rocks have been eroded, leaving only a thin cap of shale over the resistant sandstones.

At a late stage in the basin filling, older rocks of the New England Fold Belt were faulted across the basin along the Hunter-Mooki-Goondiwindi Thrust System that now marks the northeastern edge of the bioregion. The basin has also been subject to minor volcanic activity with more than 200 explosive vents (diatremes) and small basalt flows evident in the geology.

As in most parts of the Great Dividing Range, the most spectacular mountain landscape is found on the coastal side of the divide along the Great Escarpment where streams have eroded deep gorges and cliff faces back into the uplifted block. The frontal slope of the Blue Mountains is formed along the Lapstone monocline. A secondary flexure and similar escarpments occur at the coast forming the Hornsby Plateau and the Illawarra escarpment. These structural features combine with different rock types and strong trends in joint patterns to control drainage patterns and the distribution of gorges and swamps. Much of the Basin landscape is elevated sandstone plateau, with the exceptions being the Hunter Valley and the low-lying Cumberland Plain. In the south and west the Basin ends in cliff lines formed on sandstones and conglomerates of the basal Permian sediments. Waterfalls are common on all escarpments.

The post-glacial rise in sea level between 18,000 and 6,000 years ago drowned the coastal plains and river valleys to form estuaries and deep harbours now fronted by confined barrier systems of beaches, dunes and coastal lakes. Barriers have best developed at Newcastle, Kurnell and Jervis Bay and some of these areas include "cliff top" dunes that often enclose swamps and lakes formed by groundwater.

5. Geodiversity

The most significant feature of the bioregion is:

- the Great Escarpment, easily the most prominent feature of the bioregion, with its reversed drainage, and entrenched meander patterns and high level terrace gravels; the Blue Mountains are part of this feature.

At a smaller scale many interesting landscapes are present, including the following:

- the Pagoda country on deeply weathered sandstones on gorge edges;
- the gorges themselves;
- contour-patterned vegetation communities on alternating sandstones and shale plateaus;
- the concentration of volcanic vents or diatremes are significant on a world scale and these features always carry locally different vegetation;
- coastal barriers, deep estuaries and spectacular cliffs with exposed "layer cake" geology and well-developed rock platforms;
- Sydney Basin coal resources are economically critical to the state; and
- several geologic features of importance to Aboriginal people, including cultural sites of prominent landscape features, stone resources in terrace gravels and basalt outcrops, stone carving and axe grinding sites on sandstone and sandstone rock shelters.

6. Soils

The considerable range of rock types, topography and climates in the Sydney Basin has resulted in a large variety of soils and vegetation communities.

The coastal area of the bioregion consists of frontal dunes. Dunes behind this accumulate organic matter and begin to develop coloured subsoil. The oldest dunes on the inland side of the barrier and the parabolic dunes high in the landscape, even on headlands, have well-developed podsol profiles.

Limited areas of rainforest can be found in the lower Hunter, Illawarra escarpment and on Robertson basalts, as well as in the protected gorges and on richer soil in most subregions.

Species composition and structural form are similar on sandy soils of the sandstone plateaus and the sandy soils of the dunes. Better quality shale soils form caps on sandstone and on the coastal ramps.

7. Biodiversity

7.1 Plant communities

The Sydney Basin Bioregion is one of the most species diverse in Australia. This is a result of the variety of rock types, topography and climates in the bioregion.

The frontal dunes along the coastal area of the bioregion supports coast tea-tree (*Leptospermum laevigatum*), coast wattle (*Acacia longifolia*) and coast banksias (*Banksia aemula, B. serrata, B. integrifolia*), often with grass tree (*Xanthorroea* sp.) and lomandra (*Lomandra longifolia*). Dunes generally support vegetation communities dominated by old man banksia (*Banksia serrata*), smooth-barked apple (*Angophora costata*), red bloodwood (*Corymbia gummifera*) and blackbutt (*Eucalyptus pilularis*) with a diverse shrub layer. The oldest dunes, which lie on the inland side of the coastal barrier or are found as parabolic dunes high in the landscape, such as on headlands, support a mature coastal forest community.

Photo: NPWS

Estuaries are characterised by a swamp oak (*Casuarina glauca*), common reed (*Phragmites australis*), saltmarsh (*Juncus kraussii, Sporobulus virginicus,* and *Sarcocornia quinqueflora*) and mangrove (*Aegiceras corniculatum* and *Avicennia marina*) sequence. The boundaries of these communities are dynamic due to present day geomorphic processes.

Rainforest communities are characterised by coachwood (*Ceratopetalum apetalum*), native tamarind (*Diploglottus australis*), white cherry (*Schizomeria ovata*), cheese tree (*Glochidion ferdinandi*), lilly pilly (*Acmena smithii*), blackwood (*Acacia melanoxylon*) and Port Jackson fig (*Ficus rubiginosa*), with soft tree fern (*Dicksonia antarctica*) and rough tree fern (*Cyathea australis*) common in the understorey. The adjacent tall forests are dominated by Sydney peppermint (*Eucalyptus piperita*), narrow-leaved peppermint (*Eucalyptus radiata*), messmate (*Eucalyptus obliqua*), brown barrel (*Eucalyptus fastigata*), yellow stringybark (*Eucalyptus muellerana*), coastal white box (*Eucalyptus quadrangulata*), blackbutt, turpentine (*Syncarpia glomulifera*), Deane's gum (*Eucalyptus deanei*), bangalow palm (*Archontophoenix cunninghamiana*), cabbage tree palm (*Livistonia australis*), forest oak (*Allocasuarina torulosa*) and the creekline species, water gum (*Tristania laurina*).

Species composition and the structural form of the vegetation communities occupying extensive sandstone plateaus vary with altitude and rainfall. Common trees include red bloodwood, yellow bloodwood (*Corymbia eximia*), rough-barked apple (*Angophora floribunda*), smooth-barked apple, hard-leaved scribbly gum (*Eucalyptus sclerophylla*), grey gum (*Eucalyptus punctata*), black ash (*Eucalyptus sieberi*), Sydney peppermint, blue-leaved stringybark (*Eucalyptus agglomerata*), turpentine, brown stringybark (*Eucalyptus capitellata*) and northern grey ironbark (*Eucalyptus siderophloia*).

Drier, lowland environments, such as the upper Hunter, Cerrabee and Cumberland Plain support forests and woodlands dominated by forest red gum (*Eucalyptus tereticornis*), grey gum, spotted gum (*Eucalyptus maculata*), scribbly gum (*Eucalyptus haemastoma*), grey box (*Eucalyptus moluccana*), white box, yellow box (*Eucalyptus melliodora*), fuzzy box (*Eucalyptus conica*), narrow-leaved ironbark (*Eucalyptus crebra*), broad-leaved ironbark (*Eucalyptus fibrosa*), rough-barked apple, yellow bloodwood and extensive stands of swamp oak.

Riparian vegetation is dominated by river oak (*Casuarina cunninghamiana*) through most of the basin, with river red gum (*Eucalyptus camaldulensis*) occurring in the Hunter and water gum occupying the wetter, more protected environments.

Swamp vegetation ranges from monocultures of common reed to complex prickly-leaved tea-tree (*Melaleuca stypheloides*) and paperbark (*Melaleuca quinquenervia*) associations, with swamp mahogany (*Eucalyptus robusta*), swamp oak, sedges, tall spike rush (*Elaeocharis sphacelata*) and juncus (*Juncus* sp.) Hanging swamps can be found on sandstone and dunes, with the dominant species being gahnia (*Gahnia aspera*) and banksia (*Banksia robur*). A raised sphagnum bog (*Sphagnum* sp.) is located at Wingecarribee, an uncommon vegetation community in the Sydney Basin.

Coastal forest characterised by Sydney blue gum (*Eucalyptus saligna*), blackbutt, turpentine, grey ironbark (*Eucalyptus paniculata*), spotted gum, black ash and bangalay (*Eucalyptus botryoides*) occupies shale-derived soils capping sandstone and along parts of the coastal ramp. These often have an open understorey, with macrozamia (*Macrozamia communis*) and cabbage tree palm.

7.2 Significant flora

Wollemi National Park, the largest reserve in the bioregion, protects many threatened species as well as species whose distribution is restricted entirely to the bioregion. Such flora species include *Apatophyllum constablei, Acacia asparagoides, Eucalyptus bensonii* and *Rupicola decumbens,* all of which are locally endemic (NSW NPWS 2002). The recently discovered Wollemi Pine (*Wollemia nobilis*) occurs only in a very restricted part of the bioregion. It is a relict of the Gondwanan era (60-200 million years ago) found in a remote canyon in Wollemi National Park (NSW NPWS 2002). It is now listed as endangered in the TSC Act.

Important vegetation communities include yellow box – ironbark woodlands in the northern escarpments of the bioregion. These woodlands are thought to provide important habitat for species such as the regent honeyeater (*Xanthomyza phrygia*), but are not well represented in conservation reserves in the bioregion (NSW NPWS 2002). Mellong Swamp in the Wollemi National Park is another unique plant community, which provides important habitat for both reptiles and invertebrates in the bioregion (NSW NPWS 2002).

In total there are 92 vulnerable and 60 endangered plant species in the bioregion (Australian Terrestrial Biodiversity Assessment 2002).

7.3 Significant fauna

Threatened species recorded in the bioregion include the brush-tailed rock wallaby (*Petrogale penicillata*), koala (*Phascolarctos cinereus*), yellow-bellied

glider (*Petaurus australis*), brush-tailed phascogale (*Phascogale tapoatafa*), tiger quoll (*Dasyurus maculatus*), broadheaded snake (*Hoplocephalus bungaroides*), glossy black cockatoo (*Calyptorhyncus lathami*), turquoise parrot (*Neophema pulchella*) and powerful owl (*Ninox strenua*) (NSW NPWS 2002).

The Sydney Basin Bioregion is home to 2 endangered and 4 vulnerable frog species, 54 vulnerable and 14 endangered bird species, 25 vulnerable, 3 endangered and one extinct mammal species, and 11 vulnerable and 2 endangered reptile species.

Although the Sydney Basin Bioregion has the highest human population of any NSW bioregion, significant areas of native vegetation remain unchanged since European occupation. Despite this, significant rates of decline of grassland, woodland and forest bird species, as well as ground-nesting birds and ground-feeding insectivorous birds, have occurred in this bioregion. Sightings of rainforest birds, which increased significantly across Australia, did not follow this trend in the Sydney Basin despite the presence of areas of relatively intact rainforest (Australian Terrestrial Biodiversity Assessment 2002). Sightings of the rockwarbler (*Origma solitaria*), a species largely restricted to the bioregion, have been reported less frequently than in the past. Loss of forest and woodland birds around Sydney, resulting from continuing urbanisation, is a threat now and into the future (Australian Terrestrial Biodiversity Assessment 2002).

Despite declines in some native species, others such as the white-headed pigeon (*Columba leucomela*), spotted turtle-dove (*Streptopelia chinensis*), long-billed corella (*Cacatua tenuirostris*), little corella (*Cacatua sanguinea*), rainbow lorikeet (*Trichoglossus haematodus*) and noisy miner (*Manorina melanocephala*) as well as the introduced red-whiskered bulbul (*Pycnonotus jocosus*) and common myna (*Acridotheres tristis*) seem to have increased in numbers in the bioregion (Australian Terrestrial Biodiversity Assessment 2002). This is probably a result of their ability to adapt well to environments modified by humans.

Two threatened species listed in the NSW TSC Act, the ground parrot (*Pezoporus wallicus*) and the eastern bristlebird (*Dasyornis brachypterus*), have both been recorded southwest of Wollongong and near Jervis Bay in the bioregion's south, while the largest population of the endangered regent honeyeater (*Xanthomyza phrygia*) has been recorded in the north of the bioregion around the Capertee Valley. Forest and woodland birds of the bioregion are thought to be somewhat protected in Hawkesbury sandstone communities contained in conservation reserves (Australian Terrestrial Biodiversity Assessment 2002).

General threats to species in the bioregion include broad-scale vegetation clearing and loss of remnants as well as grazing by stock. Urbanisation is also a major threat to many species in the built-up areas in the bioregion.

7.4 Significant wetlands

Nine wetlands in the Sydney Basin Bioregion are regarded as being bioregionally significant (Australian Terrestrial Biodiversity Assessment 2002).

Swan Lake provides important breeding habitat for prawns and fish and is a key feeding and roosting area for waterfowl. The lake also supports an extensive area of seagrass (*Halophila ovalis* and *H. decipiens*) (Australian Terrestrial Biodiversity Assessment 2002).

Lake Conjola provides nesting habitat for a number of threatened shorebirds. These include the endangered little tern (*Sterna albifrons*) and hooded plover (*Thinornis rubricollis*) as well as the vulnerable pied oystercatcher (*Haematopus longirostris*). The lake also supports a significant area of seagrass (*Zosteraceae and Halophila*) (Australian Terrestrial Biodiversity Assessment 2002).

Lake Liddell supported over 2,000 waterbirds in 1985 and over 3,000 waterbirds in 1995 (Australian Terrestrial Biodiversity Assessment 2002). The most abundant species in 1985 were Eurasian coot and black swan (*Cygnus atratus*). In 1995, the most abundant species were Eurasian coot (*Fulica atra*), little black cormorant (*Phalacrocorax sulcirostris*), great cormorant (*Phalacrocorax carbo*) and little pied cormorant (Phalacrocorax melanoleucos). The vulnerable freckled duck (*Stictonetta naevosa*) (NSW NPWS 2001) and the endangered green and golden bell frog (*Litoria aurea*) have both been recorded at the lake.

North Avoca Swamp has also been described as bioregionally significant as it provides key habitat for the endangered green and golden bell frog (Australian Terrestrial Biodiversity Assessment 2002).

Narrabeen Lagoon and Deep Creek support the vulnerable black bittern (*Ixobrychus flavicollis*), Australasian bittern (*Botaurus poiciloptilus*), osprey (*Pandion haliaetus*) and glossy black cockatoo (*Calyptorhynchus lathami*) (Australian Terrestrial Biodiversity Assessment 2002).

Bakers Lagoon supports a range of important species including the vulnerable freckled duck, Australasian bittern (*Botaurus poiciloptilus*), black-tailed godwit (*Limosa limosa*) and black bittern (*Ixobrychus flavicollis*). There have also been sightings of a star finch (*Neochmia ruficauda*) at the Lagoon, a species that is classified as extinct under the TSC Act, as well as the endangered black-necked stork (*Ephippiorhynchus asiaticus*).

The wetlands of the Cecil Hoskins Nature Reserve are considered to be bioregionally significant. They are described as being in fair condition, although feral animals, exotic weeds, changed hydrology, and pollution due to runoff from agricultural lands threaten their status.

Brundee Swamp provides key habitat for the vulnerable Australasian bittern.

Disturbances and threats to the wetlands in the Sydney Basin Bioregion are many and varied depending on their location and include impacts from urban, agricultural and industrial development.

Decreased water quality in the wetlands results from runoff from urban areas, industrial areas, agricultural lands and rubbish tips, as well as increased stormwater and pollution from sewage treatment works. Potential spills from shipping and industries can also pose a serious risk to wetland health.

The bioregion is densely populated and pressures from recreational activities, including horse riding, jetskis and boats, fishing, erosion caused by the wash from speedboats, erosion from walking and access tracks, can threaten the biodiversity of the wetlands.

Other threats include feral animals and exotic weeds, changed fire regimes, sedimentation, salinity, weir construction and mining activities.

8. Regional history

8.1 Aboriginal occupation

Several distinct indigenous groups occupied the Sydney Basin when the First Fleet arrived in 1788. The largest of these groups were the people of the Dharug language group, although it is uncertain that this is the name they called themselves, and alternative spellings include Dharuk and Dharook (Murray and White 1988). The Dharug language group consisted of two dialects, one which was used east of Parramatta and between Sydney Harbour and Botany Bay, and the other which was spoken in the west to the

Hawkesbury, Blue Mountains and Nepean districts (the latter known as Muru-Murak or "mountain pathway"). A third group to the north of Sydney Harbour spoke the Kuringai language, while the Dharawal language region occurred from the Botany Bay south to Jervis Bay (Murray and White 1988).

The coast of the Sydney Basin Bioregion, as well as the coastlines of the other two coastal bioregions in NSW, offered a variety of environments between the sea and the ranges that were used by the Aboriginal people of the area (NSW NPWS 1980). The range of environments bore a profound influence of the lives of the Sydney Basin Aborigines. As hunters and gatherers they were reliant on their surroundings to provide food and this lifestyle affected the population size, social interactions and degree of mobility of the groups (NSW NPWS 1980). Around Sydney itself, food availability, especially fish and shellfish gathered from the sea, changed seasonally and was more reliable in summer than in winter. Further inland Aboriginal people relied on possum, vegetable roots, seeds and berries as well as mullet, eel and kangaroo (Murray and White 1988).

The Aboriginal population for the Sydney region in 1788 has been estimated as being between 5,000 and 8,000 people, of which about 2,000 belonged to the inland Dharug people: 1,000 between Parramatta and the Blue Mountains and 1,000 between what are now Liverpool and Campbelltown (Murray and White 1988). The Dharug people were thought to have lived in bands or communities of around 50 members each. Each band retained its own hunting district, and each lived a semi-nomadic lifestyle, regularly changing location within this district (Murray and White 1988). Typical dwellings were two-sided bark tents known as gunyahs throughout NSW, while sandstone rock shelters were used in harsh weather. Men of the communities were responsible for hunting possums, fish, birds and kangaroo, often collaborating with other bands to hunt and eat the larger animals. Fire was used to reduce undergrowth and to catch game. Dharug women harvested what the Europeans called yams (the community's staple) with digging sticks. Food was cooked lightly on open fires or in ovens beneath the ground.

The religion of the Dharug people took the form of a deeply spiritual association with the land and was evident in singing, dancing and stories as well as the many engravings on the flat sandstone outcrops of the Sydney Basin, some of which have remained for thousands of years. The dialects of the Dharug language were fairly complex with a rich vocabulary and grammar complete with numerous tenses. Australian English reflects the influence of Dharug people on the culture of the Sydney Basin in words such as boomerang, corroboree, dingo, koala, kookaburra, wallaby and the bush call coo-ee, which were all derived from Dharug languages.

The arrival of Europeans to the country of the Dharug people in 1788 had swift and often devastating effects on the indigenous population of the Sydney Basin. The impact was so rapid that many records and stories of the people were lost early on. Violence and the destructive effects of a small pox epidemic wiped out most of the coastal people and soon after spread to the inland Dharug communities around the Hawkesbury-Nepean area. Those who survived the epidemic that decimated much of the Dharug group went on living a semi-traditional life, often on the boundaries of European settlement (Murray and White 1988) or continued hunting on the estates that were formerly their country, supplementing their supplies with those of the new settlers. Despite this subsistence, Aboriginal numbers continued to decline and by 1827 the estimated population of 156 was around a third less than that estimated in 1788 and still declining as couples often did not have children (Murray and White 1988).

Further north in the bioregion, at the very tip where it meets the Brigalow Belt South Bioregion at what is now Towarri National Park, lay the traditional country of the Wonnarua people. The boundaries of this country, mainly in the Upper Hunter, is said to have bounded land that now includes the towns of Muswellbrook, Singleton and Scone, spanning north to Murrurundi and south to Newcastle and encompassing the upper northeast of the bioregion.

The patterns of land use undertaken by the Wonnarua differed little from those of the indigenous people in the rest of the Sydney Basin. Foods were gathered from the land and the rivers and both of these provided a rich variety of resources to the local community. Like their southern counterparts, the culture of the Wonnarua people was closely linked to their natural environment and stories, like the one below told by Tom Miller of the Wonnarua people, described the formation of the landscape (Veale 2001):

> *"When a group of warriors set out for a long journey to Broke Flats for a battle with the Kamilaroi, they left behind the old people, women and children. After the fight the remaining warriors returned to their camp. There was one girl that sat waiting and waiting for her man to return. When he didn't return she prayed to Biami to come and take her life because she could not carry on without her fellow. Biami felt sorry for the girl that never stopped crying for her man and made her into a stone feature looking down on the valley. She is still there today as part of the Wingen Maid, and the tears she cried fell upon Burning Mountain and ignited the fire that is still burning today." (Veale 2001)*

8.2 European occupation

After the initial discovery of Botany Bay in 1770, the First Fleet arrived at this shallow bay in January 1788. Governor Arthur Phillip found that Botany Bay was not a suitable location for a colony, moving the fleet further north to Port Jackson (NSW NPWS 1991) where he founded the colony at Sydney Cove. The Tank Stream was dug early on, providing a source of fresh water for the colony (HO and DUAP 1996) and soon the population of about 1,000 people lived at Sydney Cove in tents, huts or wattle and daub houses (HO and DUAP 1996).

Within a year the newly settled population had more than doubled, reaching 2,500, a rise due mainly to the transportation of convicts to the colony (HO and DUAP 1996). By this time another settlement had begun on the fertile land at Parramatta and former convicts were farming the rich alluvial land near the Hawkesbury, much to the opposition of the local Aboriginal people (HO and DUAP 1996).

Port Jackson (Sydney Harbour) held a significant place in the colony throughout the nineteenth century. It was an entry point for convicts, supplies and free settlers while goods produced by the new colony sailed out of the heads (NSW NPWS 1991). Wool, timber, gold and whale and seal products were all exported from Port Jackson at one time or another (NSW NPWS 1991).

Convicts or immigrants entering the harbour and suspected of carrying disease were, along with their ships, quarantined away from the populated areas (NSW NPWS 1991). One such place was North Head, which was used as a quarantine station for over 100 years. Fortifications were built on the major headlands to protect the harbour against attacks (NSW NPWS 1991).

The harbour provided an important means of communication. The upper reaches led to the Parramatta River, which became a vital link between the port and the farming lands in the west. Goods and people alike were transported to and from the fertile farming areas around the western town (NSW NPWS 1991).

On the south side of the harbour, transport on a rutted track along the Parramatta River allowed settlement to proceed to the west as well as south along the Cooks and Georges Rivers flowing into Botany Bay (NSW NPWS 1991). The 1820s saw the occupation of most of this land and settlers on smaller lands were forced further west by the occupation of large land holdings at Annandale, Petersham and Ultimo (NSW NPWS 1991).

The early Sydney was a wooden town replaced in time by grander, more permanent buildings (HO and DUAP 1996). Between 1810 and 1821 Governor Macquarie, with help from architect Francis Greenway, was responsible for the construction of some very grand buildings, some of which, such as the Mint Building and NSW Parliament House, still survive (HO and DUAP 1996).

In the early days of Sydney most of the colony's expenditure came from the Crown with few exports except for cedar, which was exported from 1806. However, it was in the 1820s that the new and profitable industry was discovered (HO and DUAP 1996). The hunting of whales and seals was at first a lucrative business, with shipping directly to England after the monopoly held by the East India Company was broken. When resources were drained, whaling ships were sent towards New Zealand. The shipping industry was also lucrative during the early 1800s, with so many ships leaving and arriving at Port Jackson that there began a significant market in shipping supplies. Wool also became a significant industry, and was shipped from Port Jackson, increasing the harbour's trade (HO and DUAP 1996). It was in the early to mid-1800s that the market for consumer goods was realised and the colony began processing many of its own goods, from candles and sugar, to flour, beer, pottery and bricks (HO and DUAP 1996).

The suburbs on the southern side of Sydney town developed more quickly due to ease of transport, assisted by the construction of the railway in the 1850s. Tramways constructed during the 1880s were also a factor in the development of inner suburbs. Harbour crossings by road and railway began to link the two sides of the harbour.

Most of the land between the harbour and Botany Bay was increasingly used for industry, which was attracted by the water availability in the Botany swamps (NSW NPWS 1991). In addition, the industries around Sydney were under obligation to move outside the city boundaries to avoid polluting the city due to legislation passed in 1849. As industry consumed the south and east, upper-class housing moved towards the west with the railway, settling new suburbs such as Strathfield and Summer Hill (NSW NPWS 1991).

In contrast to the bustling southern side of the harbour, the northern side remained rural and was slower to develop (NSW NPWS 1991). To the north of the harbour there were orchards and small farms with some industrial areas such as brickworks at Gore Hill in the 1870s. Many areas on the north were reliant on ferries and punts to cross the harbour or the river (NSW NPWS 1991). Governor Macquarie made an unsuccessful attempt to establish an Aboriginal farming settlement at Middle Head, named Bungarees Farm after a prominent Aboriginal man, trying in the process to "civilise" the local Aborigines (NSW NPWS 1991).

Urban development in the west was also gradual, at least initially, emerging from large farming estates used mainly for grazing and private towns on the Cumberland Plain. These were complemented by government towns such as Windsor and Narellan (HO and DUAP 1996). Parramatta, devoid of development for a long time, was considered to have become like an English country town until its eventual absorption into Sydney (HO and DUAP 1996).

The harbour remained an important resource for the people, and many feared it would become shut off to the majority of the population, with only the privileged being able to enjoy it. This prompted the government to reclaim harbour foreshores to ensure they remained in public ownership (NSW NPWS 1991). Members of the public were also concerned about the lack of public space for recreation around the new suburbs. Pushes to reserve the Lane Cove bushland around 1900 were rejected initially, but the Upper Lane Cove River area was declared parkland in 1925 (NSW NPWS 1991).

More recently, Sydney has undergone a vast population increase, and development, particularly in the west, has become rampant to cope with the increase. What were originally the far reaches of the colony have now become the outskirts of the city. Lying to the north and south of Sydney are two major coastal cities, Wollongong and Newcastle, both of which developed from industry and employed workers in steelworks run by BHP, although the Newcastle steelworks have now closed.

9. Bioregional-scale conservation

The Sydney Basin Bioregion has the third highest area of conservation-oriented tenures of the NSW bioregions. Together, they occupy about 1,384,418.33 ha or 38.20% of the bioregion.

National parks and nature reserves (under the NPW Act 1974) make the greatest contribution to the area conserved, with national parks and nature reserves occupying a total area of 1,280,935.95 ha, or about 35.35% of the bioregion. Of this area, about 1,185,498 ha is also managed under the Wilderness Act 1987 and is composed of 6 wilderness areas together occupying about 559,624.92 ha or 15.44% of the bioregion. Further recognition and protection is also given to national parks in the bioregion in the area known as the Greater Blue Mountains. This has been included on the globally recognised World Heritage list as one of three world heritage areas in NSW. Occupying approximately 1.03 million ha or almost 28.42% of the bioregion, the area is protected by international convention as well as under the Commonwealth EPBC Act 1999, which automatically protects all Australian properties that are on the World Heritage list.

Reserves under the Crown Lands Act 1989 that are managed by the National Parks and Wildlife Service contributes 1,196.23 ha to the area managed for biodiversity conservation within the bioregion.

Other lands managed under the NPW Act 1974 include: land managed as Aboriginal areas (84.80 ha or 0.002% of the bioregion); land managed as historic sites (128.34 ha or 0.004% of the bioregion); land managed as regional parks (4,675.39 ha or 0.13% of the bioregion) and land managed as state recreation areas (81,904.26 ha or 2.26% of the bioregion).

In recent years, landholders on 7 properties have entered into voluntary conservation agreements. Together the area managed permanently for conservation management occupies about 604.05 ha or 0.02% of the bioregion. Landholders on 53 properties also hold wildlife refuges, occupying 13,339.76 ha or 0.37% of the bioregion. Updated mapping (being undertaken at the time of writing) is likely to increase the area of wildlife refuges.

Landholders on 19 properties have entered into property agreements under the NVC Act (1997). The conservation zones of these agreements occupy about 386.07 ha or 0.01% of the bioregion

Nine flora reserves under the provisions of the Forestry Act 1916 contribute towards biodiversity conservation in the bioregion, occupying about 1,163.47 ha or 0.03% of the bioregion.

Also under the provisions of the Forestry Act 1916, State forests (managed primarily for forestry activities but each with various degrees of zoning from commercial forestry to conservation), occupy about 178,066.51 ha or 4.91% of the bioregion.

Three State Environmental Planning Policies operate in the Sydney Basin Bioregion: SEPP 14 (Coastal Wetlands) (13,400.29 ha or 0.37%), SEPP 26 (Littoral Rainforests) (61.82 ha or 0.002% of the bioregion) and SEPP 58 (Protecting Sydney's Water Supply) (570,111.54 ha or 15.73% of the bioregion).

10. Subregions of the Sydney Basin Bioregion

(Morgan 2001)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Hunter -	A complex of Permian shales, sandstones, conglomerates, volcanics and coal measures. Bounded on the north by the Hunter Thrust fault and on the south by cliffs of Narrabeen Sandstone. Pleistocene coastal barrier system in Newcastle bight.	Rolling hills, wide valleys, with a meandering river system on a wide flood plain. River terraces are evident, the highest with silicified gravels. Streams can be brackish or saline at low flow. Numerous small swamps in upper catchment, extensive estuarine swamps behind the coastal barrier of beach and dunes.	A variety of harsh texture contrast soils on slopes and deep sandy loam alluvium on the valley floors. Small number of source bordering dunes on southern tributaries of the Hunter. Deep sands with podsol profiles in dunes on the barrier, saline, organic muds in the estuary. Soil salinity is common on some bedrocks in the upper catchment.	Patches of rainforest brush in the lower valley. Forest and open woodland of white box, forest red gum, narrow-leaved ironbark, grey box, grey gum spotted gum, rough-barked apple and extensive of stands of swamp oak in upper reaches and foothills. River oak and river red gum along the streams. Coastal dune vegetation of blackbutt, smooth-barked apple, coast banksias and swamp mahogany. Mangroves, salt marsh and freshwater reed swamps in the estuary.
Cerrabee -	Triassic Narrabeen Group quartz and lithic sandstones and shales. Singleton coal measures exposed in valley floors. Numerous volcanic necks of Jurassic age and small areas of ridge top Tertiary basalt flows. Quaternary sandy alluvium in main valleys.	Sandstone plateau with cliffed edges into wide valleys with sandy alluvial fill. Volcanic necks form circular depressions or low domes depending on relative erodibility of adjacent rock types.	Shallow sandy profiles, bare rock outcrop on plateau. Sandy texture contrast soils on slopes, harsh texture contrast soils on coal measures, deep sands and loams in alluvium. Basalts have red brown structured loams and - clay loams, often buried - by slope debris where the volcanic necks form depressions.	Yellow bloodwood, broad-leaved ironbark, rough-barked apple, grey gum with scribbly gum and shrubs and patches of dry heath on plateau. Rough-barked apple, forest red gum, grey box, white box, yellow box, fuzzy box, with Qld blue grass and three-awned spear grass in valleys. River oak on the main streams. Volcanic necks and domes always support distinctive local vegetation, usually a box with grassy understorey.
Capertee -	Permian Shoalhaven Group conglomerates, sandstones, and shales with coal at the base of the Sydney Basin and exposure of underlying Devonian shale, siltstone or quartzite. Eastern margin of Narrabeen sandstone in cliffs. Small areas of hill top Tertiary basalt.	Wide valleys, low rolling hills below sandstone cliffs, Isolated flat top mountains in the valleys formed as pinnacles or remnant pieces of plateau. Steep, bouldery debris slope below cliffs. Shoulder slopes with stone pillars or "pagodas" above steep canyons on tributary streams falling into gorges. Low gradient swampy stream lines.	Shallow stony texture contrast profiles, usually with gritty well drained A horizons, over tough yellow or grey poorly drained clays. Bouldery debris with clay matrix below cliffs (talus). Organic sands in swamps. Red brown structured loams on basalts.	Woodlands support rough barked apple, red stringybark, red box, yellow box, Blakely's red gum with shrubby understorey and wallaby grass in open valleys. Scribbly gum, red stringybark, red box and broad-leaved ironbark on talus slopes. Black ash and Sydney peppermint on sandstone peaks. Dwarf casuarina, tea tree, and sedge on pagoda margins.

10. Subregions of the Sydney Basin Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Wollemi -	Hawkesbury Sandstone and equivalent quartz sandstones of Narrabeen Group, sub-horizontal bedding, strong vertical joint patterns. A few volcanic necks.	Highest part of the Blue Mountains. Sandstone plateau with benched rock outcrops. Creek directions controlled by jointing deep gorge of the Capertee and Wolgan Rivers.	Thin sands or deep yellow earths on plateau, thin texture contrast soils on shale benches. Organic sands in swamps and joint crevices, bouldery slope debris below cliffs, sandy alluvium in pockets along the streams. Red brown structured loams on basalts.	Red bloodwood, yellow bloodwood, rough-barked apple, smooth-barked apple, hard-leaved scribbly gum, and grey gum with diverse shrubs and heaths on plateau. Smooth-barked apple, Sydney peppermint, blue-leaved stringybark, and turpentine and gully rainforests in gullies and canyon heads. Ribbon gum and Blaxland's stringybark on basalt. River oak along main streams.
Yengo -	Triassic Hawkesbury Sandstone, valleys incised to Narrabeen sandstone, a few volcanic necks and basalt caps, Quaternary sandy alluvium and high level sands on Mellong Range and Maroota. Quaternary muddy sands in Hawkesbury upper estuary.	Benched sandstone plateau with steep slopes into narrow valleys with low cliff lines on Narrabeen sandstone. structurally controlled sub-rectangular drainage pattern. Northern end of Lapstone monocline controls Mellong Range. Hawkesbury River gorge cuts across the subregion, tributary streams dammed by levees form freshwater swamps adjacent to the river.	Shallow quartz sands on plateau, some areas of deep yellow earth and patches of podsol development on sandstone benches and in all Tertiary and Quaternary high level sands. Texture contrast soils on shales, deep clean sands in alluvium. Red brown structured loams and clay loams on basalt.	Red bloodwood, yellow bloodwood, rough-barked apple, smooth-barked apple, hard-leaved scribbly gum, and grey gum with diverse shrubs and heaths on plateau. Smooth-barked apple, Sydney peppermint, blue-leaved stringybark, and turpentine with rainforest species in gullies. Hard-leaved scribbly gum, rough barked apple and Parramatta red gum with sedge swamps on Mellong Range sand. River mangrove and grey mangrove along margins of upper Hawkesbury estuary, freshwater reed swamps with sedges and paperbarks.
Wyong -	Triassic Narrabeen sandstones, Quaternary estuarine fills, and coastal barrier complexes.	Coastal fall of the Sydney Basin, rolling hills and sandstone plateau outliers. Beach, dune and lagoons of coastal barriers interspersed with coastal cliffs and rock platforms.	Texture contrast soils on lithic sandstones and shales. Loamy sands alluvium along creeks clean quartz sands on beaches and frontal dunes, podsols in older hind dunes. Organic sands and muds in lagoons and swamps. -	Smooth-barked apple, red bloodwood, brown stringybark, Sydney peppermint, spotted gum, bastard mahogany, northern grey ironbark and grey gum on hills and slopes. Prickly-leaved tea-tree and other shrubs with swamp mahogany, swamp oak, sedges and common reed on swampy creek flats. Open heath with banksia, tea-tree, coastal wattle, black she-oak and smooth-barked apple on barrier dunes. Limited areas of grey mangrove in entrances to coastal lakes.

10. Subregions of the Sydney Basin Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Cumberland	Triassic Wianamatta groups shales and sandstones. A downwarped block on the coastal side of the Lapstone monocline. Intruded by a small number of volcanic vents and partly covered by Tertiary river gravels and sands. Quaternary alluvium along the mains streams.	Low rolling hills and wide valleys in a rain shadow area below the Blue Mountains. At least three terrace levels evident in the gravel splays. Volcanics from low hills in the shale landscapes. Swamps and lagoons on the floodplain of the Nepean River.	Red and yellow texture contrast soils on slopes, becoming harsher and sometimes affected by salt in tributary valley floors. Pedal uniform red to brown clays on volcanics. Poor uniform stony soils, often with texture contrast profiles on older gravels, high quality loams on modern floodplain alluvium.	Grey box, forest red gum, narrow-leaved ironbark woodland with some spotted gum on the shale hills. Hard-leaved scribbly gum, rough-barked apple and old man banksia on alluvial sands and gravels. Broad-leaved apple, cabbage gum and forest red gum with abundant swamp oak on river flats. Tall spike rush, and juncus with Parramatta red gum in lagoons and swamps.
Pittwater	Triassic Hawkesbury Sandstone with thin ridge cappings of Ashfield Shale. Narrabeen sandstones exposed in valleys and along the coast. Quaternary coastal sands.	Hornsby plateau of quartz sandstone with occasional shale caps. Small beach, dune and lagoon barrier systems. Steep coastal cliffs and rock platforms.	Deep yellow earths or rocky outcrop on plateau tops. Uniform and texture contrast soils on sandstones and shale slopes. Loamy sands in alluvium along creeks, clean quartz sands with moderate shell content on beaches and frontal dunes. Organic sands and muds in estuaries.	Shale caps support tall forest of Sydney blue gum and blackbutt or turpentine and grey ironbark. Sandstone plateau; Sydney peppermint, smooth-barked apple, scribbly gum, red bloodwood, yellow bloodwood, with diverse shrubs and patches of heath. Blackbutt, turpentine, coachwood and water gum in deep sheltered gullies. Spotted gum, Deane's gum, bangalow palm, and forest oak on Narrabeen sandstone lower slopes. Banksia, tea-tree heath on dunes. Bangalay, swamp mahogany, cabbage tree palm, swamp oak, common reed and cumbungi in fresh swamps. Mangrove and saltmarsh communities in quiet estuaries.
Burragorang	Permian and Triassic sandstones and shales on the western edge of the Basin. Limited basalt caps.	Rolling hills on a sandstone plateau with deep gorges and sandstone cliffs in Burragorang valley.	Rocky outcrops, texture contrast soils and uniform sands on sandstone. Bouldery debris with sandy clay matrix below cliffs. Rich loams in alluvium.	Heath, shrubland and woodland with black ash, hard-leaved scribbly gum, Sydney peppermint and red bloodwood on sandstone similar to other parts of the Basin. Deane's gum, turpentine, blue-leaved stringybark immediately below escarpment passing to grey gum, narrow-leaved ironbark and thin-leaved stringybark on bouldery slopes. River oak along main streams below the plateaus.

10. Subregions of the Sydney Basin Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Cataract -	Triassic Hawkesbury Sandstone on the coastal edge of the Basin above the Illawarra escarpment. Quaternary sands and muds in Georges River and Botany Bay.	Sandstone plateau with shallow creeks flowing through hanging swamps in the highest parts ramping down to low hills in the Georges River and Botany Bay. Coastal cliffs north of the Illawarra. Large barrier system with beach, dunes, swamps, and estuary at Kurnell.	Deep sands and clayey sands with peat in hanging swamps, yellow earths on better drained sandstone ridges. Siliceous sands in younger dunes and well developed podzols in older dunes. Organic sands in swamps and estuary.	Red bloodwood and black ash woodland with abundant shrubs on sandstone with extensive gahnia, banksia in hanging swamps. Coastal dune sequence of tea-tree, coast wattle, smooth-barked apple, blackbutt and swamp mahogany on barrier system. Mangroves and salt marsh on Towra Point and up the Georges River estuary.
Moss Vale -	Triassic Wianamatta Group shales, Tertiary basalts and trachyte intrusions, large Quaternary peat swamp.	Shale and basalt plateau with rolling hills and shallow valleys. Very large peat swamp at Wingecarribee.	Structured red and red-brown clay loams and loams, and loamy alluvium with high fertility. Areas of sandstone at the margins thin, waterlogged sandy soils. Organic peat in swamps. Stony slope debris on larger intrusions.	Tall forest of narrow-leaved peppermint, Sydney peppermint, monkey gum, black ash, messmate, coastal white box, and brown barrel on shale and basalts. Extensive sedgelands and hanging swamps on sandstone. Wingecarribee raised sphagnum bog. Sydney peppermint, narrow-leaved peppermint, and gully ash on trachyte domes.
Illawarra -	Permian siltstones, shale, sandstones and interbedded volcanics on and below the coastal escarpment. Quaternary alluvium and coastal sands.	Vegetated cliff faces on coastal escarpment with waterfalls and steep streams. Bouldery debris slopes with sandy clay matrix and low hills and alluvial valleys on coastal ramp. Barrier systems at Lake Illawarra and Nowra.	Structured red and red brown loams and clay loams with some areas of mellow texture contrast soils. Fertility high and good water holding capacity. Siliceous sands on beaches and dunes, podsol profiles in older dunes, peaty sands and organic silts in swamps - and estuaries. -	Mixed warm temperate and subtropical rainforest complexes on rich shale soils and alluvium under the escarpment. Coachwood, native tamarind, cabbage tree palm, Port Jackson fig, cheese tree, with soft tree fern and rough tree fern understorey. Adjacent tall forests; Sydney peppermint, brown barrel, yellow stringybark coastal white box. Coastal dunes; coast wattle, tea-tree, banksia, and blackbutt. Common reed in fresh swamps and lakes, mangroves and limited saltmarsh in estuaries.
Ettrema -	Permian horizontal quartz sandstone alternating with shales. Deep gorges expose Silurian volcanics and Carboniferous granite in underlying Lachlan Fold Belt. Limited Tertiary basalt with river gravels.	Low stepped hills on plateau with deeply incised streams off plateau edge below waterfalls on the escarpment.	Alternating sandstone and shale create bare rock benches and soil benches with shallow, often saturated sand. Structured red brown clay loams on basalt.	Very prominent “contour” vegetation pattern. Lichens, mosses and low heath patches on rock, woodlands with dwarfed red bloodwood, black ash, tall heath and sedgeland on soil benches. Better soils have messmate and brown barrel. Gullies support rainforest elements with turpentine plumwood, coachwood, lilly pilly and mountain pepper.

10. Subregions of the Sydney Basin Bioregion *CONTINUED*

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Jervis	Permian quartz sandstone and mixed shale and lithic sandstones. Tertiary trachyte intrusives at Milton. Limited Tertiary sands and more extensive Quaternary coastal sands.	Escarpment faces west and south and sandstone plateau rises to small peaks like Pigeon House. Waterfalls and gorges off the escarpment but low hills and coastal ramp on siltstones to Jervis Bay. Well developed coastal barrier with Jervis Bay enclosed by tied islands. Pleistocene cliff top dunes on the peninsula with fresh lakes created by water table windows.	Poor shallow sands on quartz sandstone plateau similar to Ettrema. Deep texture contrast soils with loam topsoils on coastal shales, moderate fertility but waterlogged valley floors. Coastal barriers extend from clean dune sands to deep podsols in Pleistocene dunes. Organic sands and muds in swamps and estuary.	Coastal forests on shale dominated by spotted gum, blackbutt, black ash, and bangalay. Rainforest elements on trachyte, watergum along streams. Open understorey with macrozamia. Sand dunes have barrier sequence of tea-tree, banksia, wattles merging to protected forests and scrubs with smooth-barked apple, red bloodwood, forest oak, bangalay and blackbutt. Gahnia sedgelands with black wattle in steep wet gullies. Common reed swamps and sedgeland in wide valleys on shale and behind dunes. Swamp oak, salt marsh and mangrove sequence in estuaries.

Photo: NPWS

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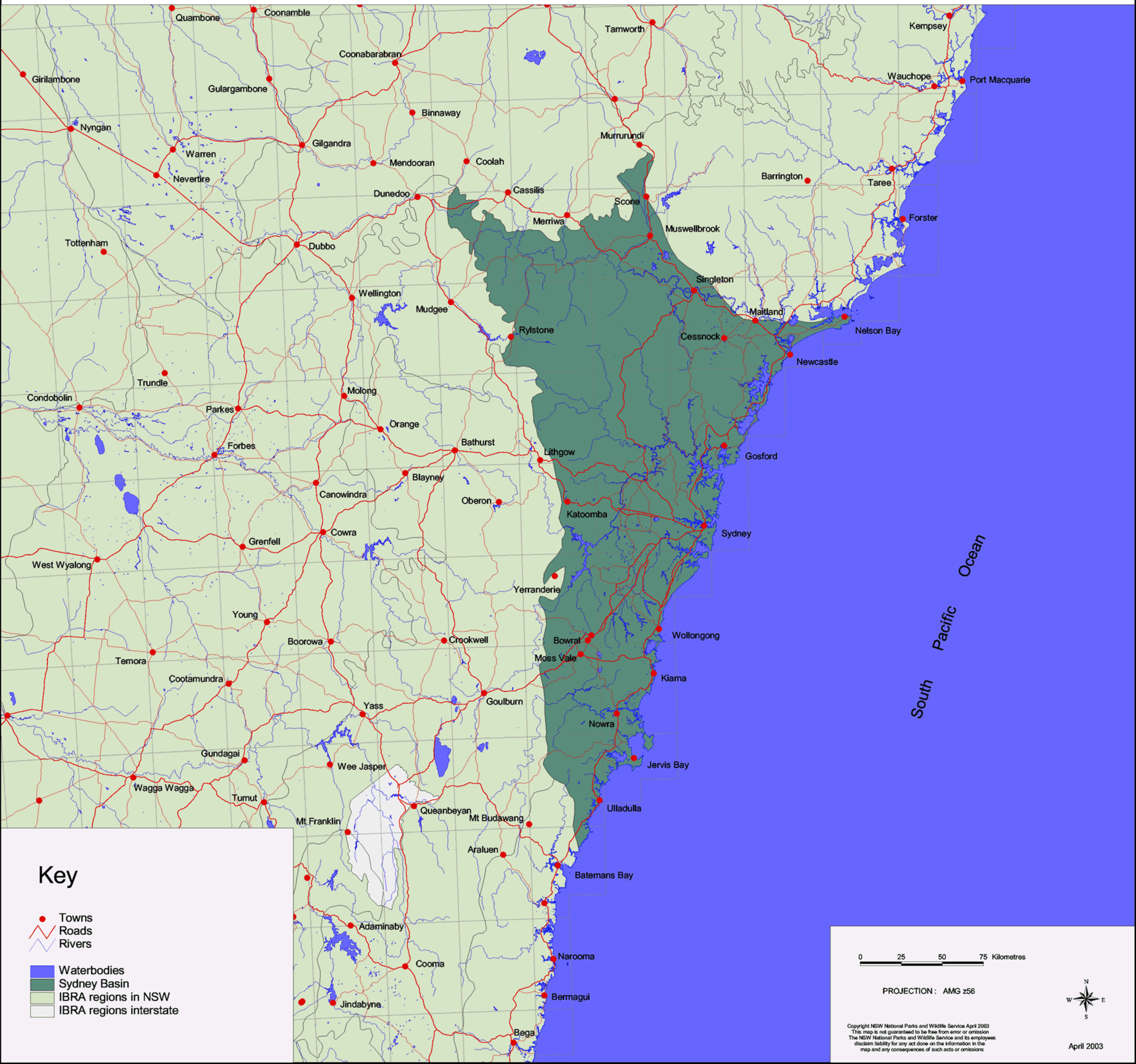
Sydney Basin

Sydney Basin Biogeographic Region (IBRA) - Location



Key

- Towns
- Roads
- Rivers
- Waterbodies
- Sydney Basin
- IBRA regions in NSW
- IBRA regions interstate

0 25 50 75 Kilometres

PROJECTION : AMG z56

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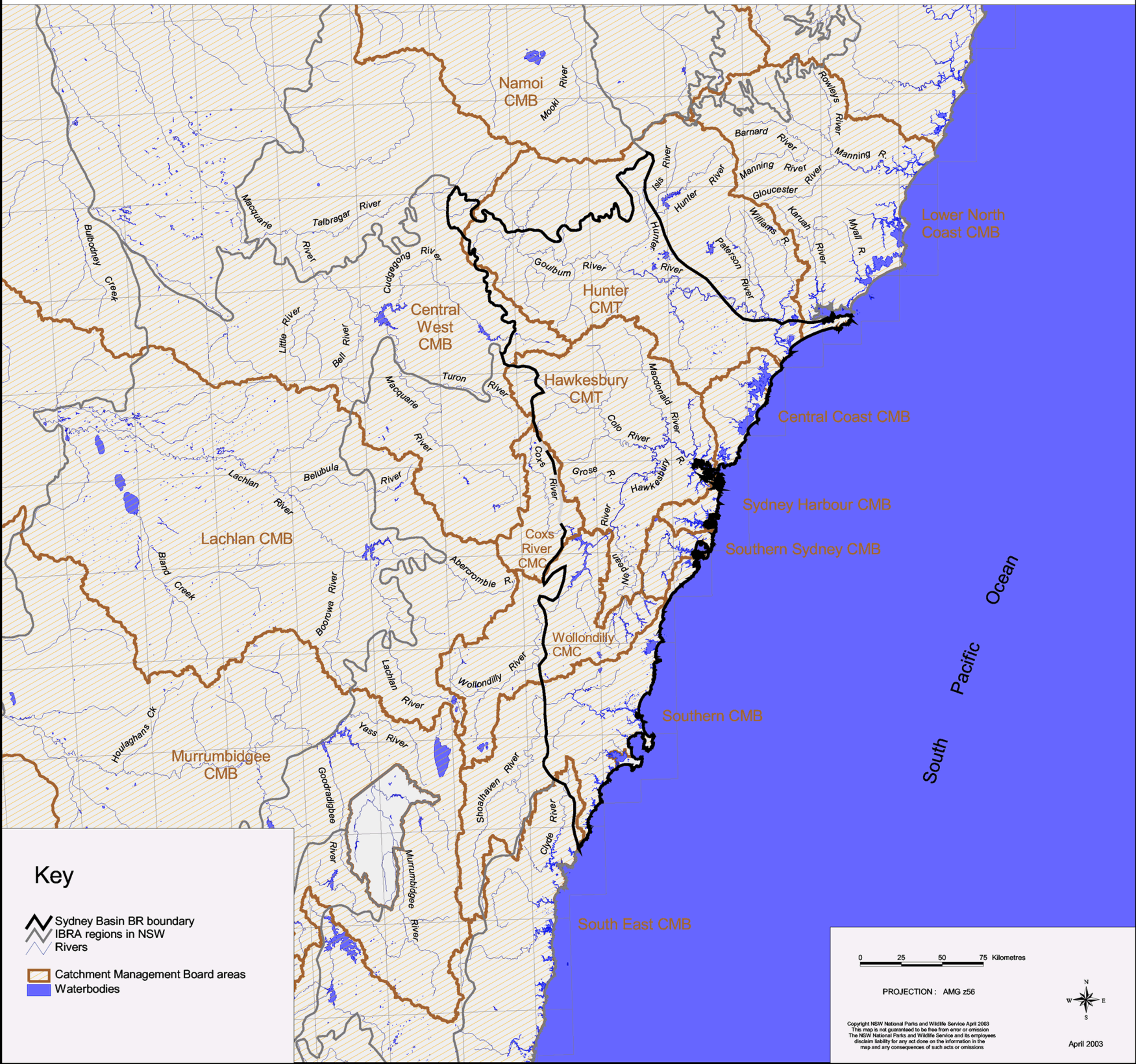
April 2003

Sydney Basin Biogeographic Region (IBRA) - Rivers



Key

- Sydney Basin BR boundary
- IBRA regions in NSW
- Rivers
- Catchment Management Board areas
- Waterbodies

0 25 50 75 Kilometres

PROJECTION : AMG z56

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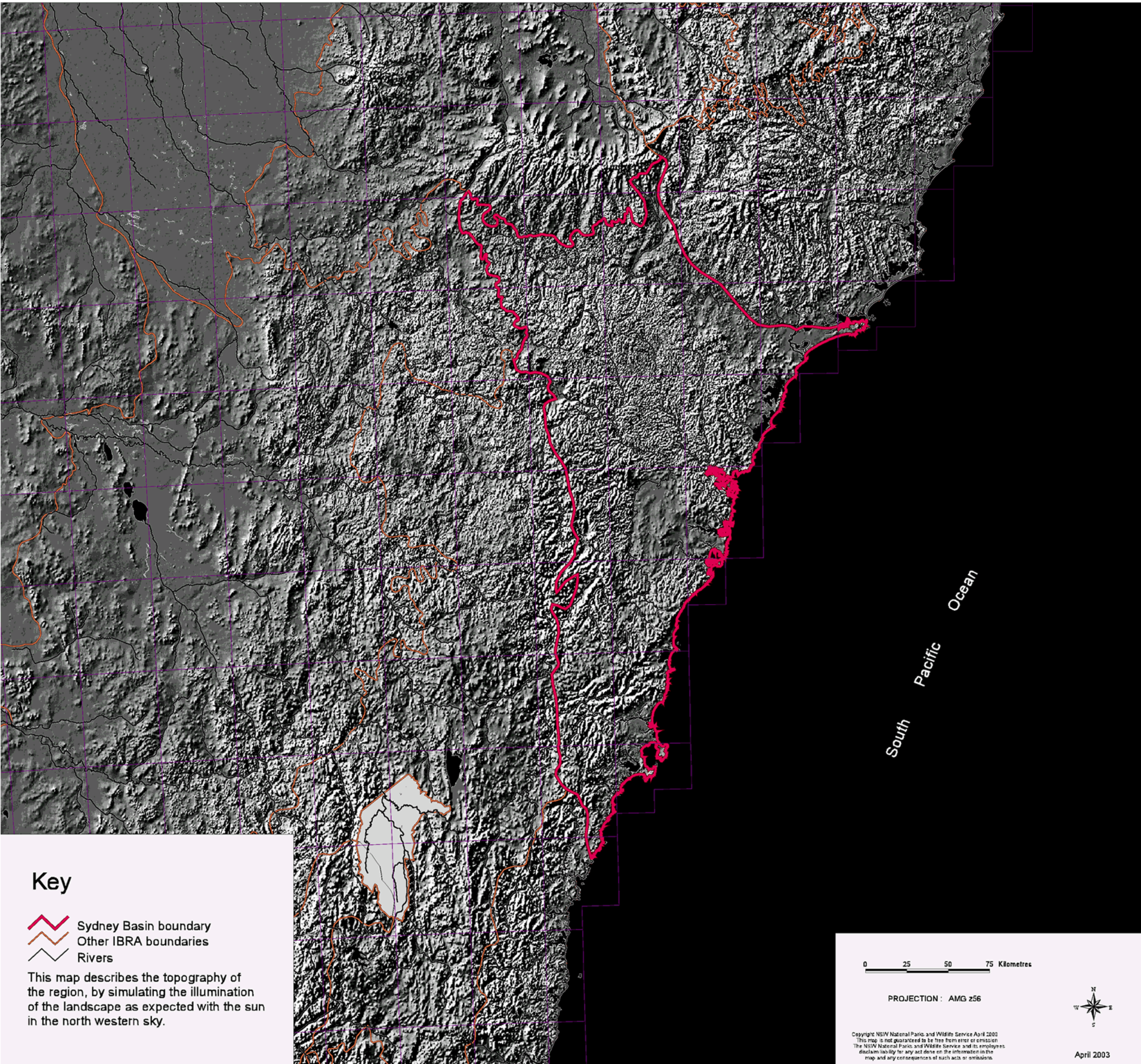
April 2003

Sydney Basin Biogeographic Region (IBRA) - Topography



Key

Sydney Basin boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

0 25 50 75 Kilometres

PROJECTION : AMG z56

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April 2003

Sydney Basin Biogeographic Region (IBRA) - Vegetation

Sydney Basin Biogeographic Region (IBRA) - Tenure/Reserves

South Pacific Ocean

Key

- Sydney Basin BR boundary
- IBRA regions in NSW
- Roads
- Rivers

- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

0 25 50 75 Kilometres

PROJECTION : AMG z56

N W E S

April 2003

Sydney Basin Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)

Key

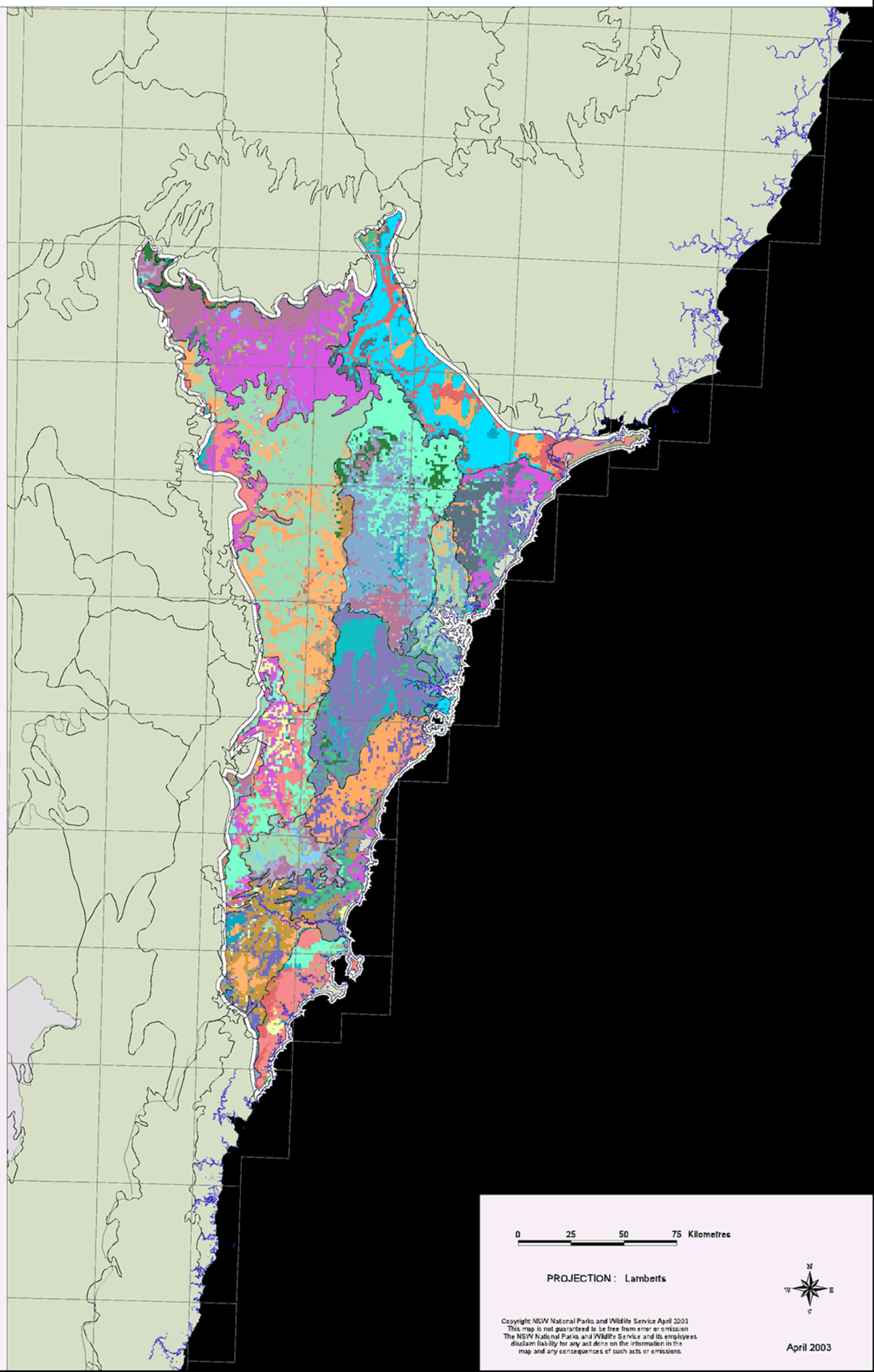
Subregions (IBRA)
Sydney Basin

IBRA regions in NSW
IBRA regions interstate

Landscapes

266, 268, 270, 271, 334, 388, 400, 433, 436, 456, 481, 508, 510, 532, 543, 553, 557, 568, 569, 573, 578, 584, 585, 587, 589, 590, 591, 592, 593, 594, 609, 610, 614, 620, 626, 629, 631, 632, 634, 635, 637, 638, 640, 641, 642, 643, 645, 647, 648, 649, 650, 651, 652, 653, 656, 660, 661, 662, 663, 665, 666, 669, 671, 680, 687, 688, 689, 690, 691, 692, 693, 694, 696, 698, 699, 700, 701, 703, 704, 705, 707, 708, 712, 714, 717, 718, 720, 722, 724, 727, 732, 733, 737, 739, 740, 741, 742, 745, 746, 747, 748, 749, 750, 751, 752, 753, 757, 772, 780, 781, 782, 783, 790, 794, 795, 806, 807, 809, 810, 818, 827, 836, 839, 841, 844, 845, 846, 847, 848, 849, 850, 851, 858, 859, 863, 866, 867, 869, 879, 880, 883, 885, 887, 888, 891, 894, 895, 912, 913, 917, 918, 919, 920, 924, 925, 926, 927, 930, 931, 932, 935, 937, 939, 940, 942, 943, 944, 945, 946, 947, 948, 949, 954, 955, 957, 958, 959, 961, 962, 963, 964, 966, 968, 971, 972, 973, 975, 976, 982, 983, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000, 1001, 1003, 1005, 1006, 1011, 1012, 1016, 1017, 1019, 1020, 1021, 1022, 1023, 1026, 1028, 1029, 1038, 1039, 1044, 1045, 1046, 1047, 1049, 1060, 1064, 1068, 1071, 1072, 1079, 1080, 1084, 1085, 1087, 1091, 1099

* A description of each landscape, identified by these landscape codes, is available in 'State Conservation Monitoring Project - Monitoring NSW Environments' (NPWS, in preparation)



April 2003

CHAPTER 16

The South Eastern Highlands Bioregion

1. Location

The South Eastern Highlands Bioregion lies just inland from the coastal bioregions of the South East Corner and the Sydney Basin, bounded by the Australian Alps and South Western Slopes bioregions to the south and west. The bioregion includes most of the ACT and extends south into Victoria.

With a total area of about 8,749,155 ha (IBRA 5.1), 55.9% or 4,888,633 ha of the South Eastern Highlands Bioregion lies in NSW. The bioregion occupies approximately 6.11% of the state.

The bioregion includes the towns of Orange, Bathurst and Lithgow in the north, Goulburn, Queanbeyan and Yass in the centre and Cooma, Jindabyne and Bombala in the south.

The Lachlan, Macquarie, Murray, Murrumbidgee, Shoalhaven and Snowy Rivers all flow across the bioregion.

2. Climate

This bioregion is dominated by a temperate climate characterised by warm summers and no dry season. Significant areas in the north and south of the bioregion are at higher elevations in a montane climate zone, where summers are much milder.

3. Topography

The South Eastern Highlands Bioregion covers the dissected ranges and plateau of the Great Dividing Range that are topographically lower than the Australian Alps, which lie to the southwest. It extends to the Great Escarpment in the east and to the western slopes of the inland drainage basins. The bioregion continues into Victoria. The substrate is formed of Palaeozoic granites, metamorphosed sedimentary rocks and Tertiary basalts.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
6 – 16°C	-3.8 – 4.7°C	18 – 31.3°C	460 – 1883mm	23 – 98mm	55 – 220mm

4. Geology and geomorphology

The highlands are part of the Lachlan fold belt that runs through the eastern states as a complex series of metamorphosed Ordovician to Devonian sandstones, shales and volcanic rocks intruded by numerous granite bodies and deformed by four episodes of folding, faulting and uplift. The general structural trend in this bioregion is north-south and the topography strongly reflects this. There are four centres of Tertiary basalt flows.

The oldest rocks are a small sliver of the Early Ordovician serpentinite running from Gundagai past Tumut into the lower Snowy Mountains. These unusual rocks were formed in deep marine conditions and were plastered against the edge of Australia when an area of sea floor and an island arc closed up. A similar sequence is found at Lucknow, about 9km south-east of Orange.

The largest island arc environment is the late Ordovician Molong Volcanic Arc that extends from the northern end of the bioregion to Kiandra. This contains mixed sediment deposited from massive submarine landslides (turbidites) interbedded with quartz sandstone and basaltic tuffs. The sequence is intruded by gabbro, dolerites and later granites. Most granite bodies are oriented parallel to the general north-south structural trend, but the youngest bodies, like the Bathurst granite (about 325 million years old) cut across this trend.

In the Devonian, the region was open sea accumulating fine sediment now represented by shales, sandstone and volcanic sediments in a series of parallel troughs such as at Tumut, Hill End, and from Captains Flat to Goulburn. The whole rock sequence is highly mineralised and contains many large base metal and gold deposits of economic importance.

In the Tertiary, volcanic activity was widespread and there are large areas of associated river sands and gravels in the mid-Shoalhaven valley. Canobolas was a central volcano 50 km in diameter now eroded to reveal more than 50 remnant vents, plugs, dykes, and trachyte domes.

The largest lava fields are found on the Monaro where 65 eruption centres have been identified. These flows are very thin and are interbedded with river and lake sediments. They have been dated as 34-55 million years old. In the Snowy Mountains an inverted relief pattern of 18-20 million year old hill top flows burying river gravels was worked for gold at Kiandra. Similar flows preserving old valleys are found at Crookwell, Abercrombie, Nerriga and in the Macquarie Valley.

Topographically, the dominant features of the bioregion are plateau remnants, granite basins with prominent ridges formed on contact metamorphic rocks and the western ramp grading to the South Western Slopes. Streams cutting through the bioregion are deeply entrenched with only a few terrace features. Valleys are narrow and there is little Quaternary sediment except in the numerous lake basins of the Monaro province.

5. Geodiversity

There are numerous localities exposing structural features in the bedrock, such as the following:

- state circle faults in Canberra;
- complex folds in a railway cutting at Captains Flat;
- the mid-Devonian cauldron subsidence of the Bindook porphyry complex;
- mega debris flow blocks up to 1 km wide of Nubrigyn limestones at Molong; and
- the entire Canobolas volcanic field with numerous plugs and dykes.

The bioregion also holds important examples of rare rock types, such as:

- serpentinites in the Gundagai – Tumut belt and Lucknow; and
- a suite of metamorphic rocks associated with complex dioritic intrusions at Hartley.

Other significant features include the following:

- mine sites such as Adelong, Captains Flat, Burraga, Cadia, Sunny Corner and Hill End and their associated heritage;
- karst systems, deep limestone gorges and fossil sites in limestone are also significant, for example, Yass, Abercrombie, Bungonia, Wombeyan, Jenolan, Borenore, Molong and elsewhere;
- important Quaternary vertebrate fossil sites occur in swamps on the Monaro plateau; and
- numerous shallow or dry lake basins with lunettes and fossil high water strand lines occur in the bioregion; the best known examples are Lake George and Lake Bathurst, but similar features are found all over the Monaro and as far north as Bathurst; research at Lake George has revealed a story of climate and environmental change well into the Quaternary and all such lakes have potential for similar research.

6. Soils

Soils vary across the bioregion in relation to altitude, temperature and rainfall. On the Palaeozoic slates, sandstones and volcanics, mottled red and yellow texture contrast soils, with red earths are found. On the granites, shallow red earths occur on ridges, yellow texture contrast soils on all slopes and deep coarse sands in alluvium. On Tertiary basalts, shallow red-brown to black stony loams exist, with alluvial loams and black clays in swampy valley floors. Limited areas of shallow organic loams are present at high altitude on Canobolas. Some of the tertiary sands in the mid-Shoalhaven deep have been worked into low dunes under a past climate and now have deep siliceous sand or yellow earth profiles.

7. Biodiversity

7.1 Plant communities

Both soils and vegetation vary across the bioregion in relation to altitude, temperature and rainfall. Temperature affects the vertical distribution of species and can be observed in inverted sequences in frost hollows.

Diverse vegetation communities occur across the bioregion, including those consisting of yellow box (*Eucalyptus melliodora*), red box (*Eucalyptus polyanthemos*) and Blakely's red gum (*Eucalyptus blakelyi*), with areas of white box (*Eucalyptus albens*) occupying lower areas. Red stringybark (*Eucalyptus macrorhyncha*), broad-leaved peppermint (*Eucalyptus dives*) and white gum (*Eucalyptus rossii*) associations dominate hills in the west of the bioregion. Brown barrel (*Eucalyptus fastigata*) communities are more common in the east. River oak (*Casuarina cunninghamiana*) is seen along main streams. Grey gum (*Eucalyptus punctata*) and Blaxland's stringybark (*Eucalyptus blaxlandii*) are found on lower areas, and brown barrel, mountain gum (*Eucalyptus dalrympleana*), narrow-leaved peppermint (*Eucalyptus radiata*) and ribbon gum (*Eucalyptus viminalis*) occur on higher areas. Small areas of Argyle apple (*Eucalyptus cinerea*) can be found near Goulburn. Patches of snow gum (*Eucalyptus pauciflora*) occur in the highest places in cold air pockets. High diversity swamps occur on the Boyd Plateau with Carex appressa and tea tree (*Leptospermum myrtifolium*) and sphagnum bogs in the streams. Dwarf casuarina (*Casuarina nana*), tea tree (*Leptospermum lanigerum*) and Calytrix tetragona heath are present on the dry aspects of ranges at the head of the Shoalhaven River.

Granite-derived soils support apple box (*Eucalyptus bridgesiana*), yellow box, some white box and red stringybark associations, with ribbon gums on the lower slopes and brown barrel occurring in the eastern parts of the bioregion. Rocky outcrops support patches of black cypress pine (*Callitris endlicheri*), whereas cold plateaus support open woodlands of snow gum and black sallee (*Eucalyptus stellulata*), with grasslands on the Monaro. River oak is widespread along streams.

Soils derived from Tertiary basalts support vegetation communities dominated by yellow box and Blakely's red gum, with red stringybark, white gum and broad-leaved peppermint across most of the Canobolas plateau. Ribbon gum and candle-bark gum (*Eucalyptus rubida*) associations dominate the lower slopes, while snow gum and mountain gum occupy cold patches and the high altitudes of Canobolas. Extensive grasslands are common on the driest plains of the Monaro, the characteristic species being snow grass (*Poa sieberiana*), spear grasses (*Stipa scabra* and *Stipa variabilis*), kangaroo grass (*Themeda australis*) and wallaby grass (*Danthonia* sp.). Clumps of snow gum can also be found among rocky outcrops.

Areas of sandy soils in the mid-Shoalhaven support woodlands of broad-leaved peppermint, snappy gum (*Eucalyptus racemosa*), forest oak (*Allocasuarina torulosa*), *Banksia marginata* and *Banksia integrifolia*.

7.2 Significant flora

There are 88 species listed in the schedules of the TSC Act in the South Eastern Highlands Bioregion (NSW NPWS 2001). Of these, 36 are listed as endangered, 50 are listed as vulnerable, and 2 species, *Stemmacantha australis* and *Galium australe*, are considered extinct.

Eucalyptus recurva is one threatened species that is also endemic to the bioregion. It has been described as the rarest of all eucalypts and is known from only 3 stands in the South Eastern Highlands (NSW NPWS 1999a). The plumed midge orchid (*Genoplesium plumosum*) is also endemic to the bioregion, known from only 6 colonies east of Marulan (NSW NPWS 1999b). *Grevillea wilkinsonii*, located east of Tumut, is also endemic to the bioregion.

7.3 Significant fauna

Eighty-eight fauna species from the South Eastern Highlands Bioregion are listed in the schedules of the TSC Act (NSW NPWS 2001). Of these, 25 are listed as endangered and 63 are listed as vulnerable.

A noticeable decline in the numbers of the endangered regent honeyeater (*Xanthomyza phrygia*) in the bioregion is illustrative of a general decline in woodland bird species such as robins, treecreepers and many small honeyeaters (Australian Terrestrial Biodiversity Assessment 2002). These declines have been attributed to fragmentation of the landscape, which in this bioregion tends to occur at the edges of largely intact remnants.

This contrasts with substantial increases in noisy miner (*Manorina melanocephala*), Australian magpie (*Gymnorhina tibicen*) and grey butcherbird (*Cracticus torquatus*). These trends are consistent with those that might be expected in a fragmented landscape with a gradual decay in diversity in remnant patches, a decay that may only become evident over decades. Over 7% of all observations were of introduced taxa, with the

Photo: NPWS

bioregion being particularly important for the Eurasian tree sparrow (*Passer montanus*), common blackbird (*Terdus merula*), song thrush (*Terdus philomelos*) and common myna (*Acridotheres tristis*). The last species was recorded much more frequently in the second Atlas period than in the first. Although there was no decline in reporting rate apparent among those taxa that specialise in rainforest, temperate forest or temperate woodland, generalists did decrease, perhaps suggesting there has been little change in the high quality areas, but that gradual environmental degradation is occurring across the broader landscape.

7.4 Significant wetlands

There were no bioregionally significant wetlands recorded in the NSW part of the South Eastern Highlands Bioregion (Australian Terrestrial Biodiversity Assessment 2002). A number of wetlands in the bioregion are regarded as nationally important and listed in the Directory of Important Wetlands in Australia (ANCA 1996).

These wetlands are exposed to a variety of threats including exotic weed invasion, feral animals, grazing pressure, sedimentation and changed water regimes. Four-wheel driving and camping can also threaten the biodiversity of wetlands in the bioregion.

8. Regional history

8.1 Aboriginal occupation

The major Aboriginal groups that traditionally occupied the South Eastern Highlands Bioregion were the Walbanga in the centre, Ngarigo in the centre and southern parts of the bioregion, and Ngunawal and Gandangara in the north of the bioregion (HO and DUAP 1996). Other groups were the Walgal towards the west of the bioregion near the northern part of Kosciuszko National Park, and the Bidawal, a coastal group whose homeland extended inland to the south of Bombala. These inland groups were more nomadic than the coastal groups, perhaps because of the less plentiful food supply away from the coast. The people of the South Eastern Highlands Bioregion relied on the continuous supply of vegetables available in the tablelands. Spring, summer and autumn yielded the tubers of the yam daisy, wattle-seeds were plentiful in July and August, and orchid tubers were consumed in August and September (HO and DUAP 1996). Fish and crayfish were taken from the rivers from September to May, while possums and larger grazing animals were hunted throughout the year.

The Aboriginal groups around the centre of the bioregion made an annual pilgrimage in December and January to the Bogong Mountains and Snowy Mountains where the men of various groups participated in feasts of roasted bogong moths (*Agrotis infusa*) high on the rocky granite outcrops of the mountains.

The nomadic lifestyle of the Aboriginal people, so dependent on the land of the South Eastern Highlands Bioregion, was disrupted by the arrival and early settlement of Europeans in the 1820s. From this time on, there were reports of diminishing water, fish and native animals so important to the Aboriginal diet (HO and DUAP 1996). Some Aborigines adapted to the change by taking on work for the new settlers such as washing sheep, cutting bark and picking potatoes, while others chose to remain on the land and continue hunting.

The new settlers not only changed the lifestyle of Aboriginal people, but also their health which was affected by exotic diseases which devastated many populations, particularly the influenza epidemic in 1846-7 and syphilis (HO and DUAP 1996). Eight centuries of tradition in the bioregion's Aboriginal communities were destroyed within 50 years. The bogong moth ceremonies ceased and intertribal meetings and corroborees also came to an end. Traditional Aboriginal life in the bioregion is considered to have ended by 1850 (HO and DUAP 1996). The *Sydney Morning Herald* reported in 1856 that the Aboriginal people in the south of the bioregion were extinct but the census indicated 166 Aborigines (likely to have been Ngarigo) around Cooma and 319 near Bombala (most probably Bidawal). The well-known Bony Jack and his son Biggenhook were surviving members of the Ngarigo people, with Biggenhook living into the twentieth century, a firm supporter of the Cooma Cricket Club. Ngarigo numbers were dwindling by this time and when Biggenhook died in 1914 at the age of 62, the Ngarigo people became extinct.

8.2 European occupation

The South Eastern Highlands Bioregion was first explored between 1817-20 by Hamilton Hume, Charles Throsby, James Meehan and John Oxley who indicated that the area showed clear potential for grazing and agriculture (HO and DUAP 1996). Soon after this exploration, land was settled in the area throughout the 1820s. John Macarthur settled Taralga in 1822, various Scots arrived in the Braidwood area in the 1830s, and almost 10,000 cattle and sheep were farmed in the open country around Goulburn in 1821. The 1830s saw the whole southern area of the bioregion occupied by squatting runs (HO and DUAP 1996).

Goulburn was earmarked as a town by 1828, founded between 1829 and 1833, and had a population of 650 by 1841, which almost doubled by 1845 (HO and DUAP 1996). Bathurst, in the north of the bioregion, was established in 1833 and the site of Orange chosen by 1846 (HO and DUAP 1996). Bombala was a successful town with 300 residents by the 1850s. Cooma was gazetted as a town in 1849 and grew quickly. By 1889, it was linked to the rail line from Goulburn (HO and DUAP 1996). Other towns such as Bungonia and Marulan developed gradually or did not flourish while towns such as Bungendore and Braidwood were dependent on the crafts industry. Although slow to prosper in the depression of the 1840s, Braidwood blossomed with the advent of the gold rush in 1851 and many shops, banks and hotels experienced a boom, as did the agricultural industry (HO and DUAP 1996). At the turn of the century,

Photo: Peter Hitchcock

when this progressive period ended, Braidwood's eminence soon faded, although its heritage remains as the basis for tourism in the area. Gunning and Gundaroo have similar histories.

Yass developed as an agricultural centre after gazettal in 1837 and has remained established into the twenty-first century along with Crookwell, which developed later after the initial drive from the gold rush of the 1850s, becoming the local centre for wheat growing from the 1860s onwards (HO and DUAP 1996). Sofala, another town based on the gold rush of 1851-2, had a cosmopolitan population although the town itself was reasonably short-lived when the population growth shifted to Hill End in the 1870s as this area began to dominate in gold-mining (HO and DUAP 1996).

The copper rush from the 1840s to the late 1890s also had an impact on the bioregion. The area particularly in the north of the bioregion has the longest history of copper mining in NSW (HO and DUAP 1996). Copper was first discovered in the bioregion at Copper Hill south of Molong in 1845 and was also found at several locations throughout the region, including Carcoar, Sunny Corner and Blayney. Gold, silver, antimony and zinc were also mined at Sunny Corner, the landscape now barren and almost sterile from the lead and arsenic produced from the smelting of silver ores.

Crops and orchards have been common in the South Eastern Highlands ever since miners in the area planted apple, plum and cherry trees near Batlow in the 1850s and 60s, although the first commercial orchard of the area was not planted until 1895 (HO and DUAP 1996). By 1907, there were 5,000 fruit trees in the area and more orchards continued to be planted. Batlow benefited from this attention and was declared a town in 1910. The advent of the railway to the area in 1923 further enhanced it as a prominent fruit-growing district (HO and DUAP 1996).

When the railway reached Lithgow in the 1870s it managed to transform the sleepy rural town into one of the major industrial towns in the state. The local coal mine, Western Coalfield, began to realise its true economic potential as coal could now be transported by rail. Lithgow also benefited in 1900 from the opening of the first steelworks in Australia followed by the first modern iron ore blast furnace built there in 1906-7 (HO and DUAP 1996). These days, since the coalmines have closed and the wool industry has shifted, Lithgow owes much of its current existence to nearby electric generating stations at Wallerawang and Mt Piper and their open-cut coalmines (HO and DUAP 1996).

The Snowy Mountains Hydro-Electric Scheme considerably altered the bioregion (as well as the adjacent Australian Alps Bioregion) from 1949, both physically and demographically. Construction of the scheme began at Adaminaby on 17 October 1949 and was completed 25 years later in 1974 (Department of Immigration website – http://www.immi.gov.au/).

The purpose of the Scheme was to use the rivers of the Snowy Mountains to produce electricity as well as to divert water from the coastal rivers for use in irrigation around the Murray and Murrumbidgee catchments (Australian Science and Technology Heritage Centre website – www.austehc.unimelb.edu.au). More than 100,000 men and women from over 30 countries worked on the scheme during its planning and construction, the workforce reaching a peak in 1959 with 7,300 people (Snowyhydro renewable energy website – www.snowyhydro.com.au/).

Australians (including indigenous Australians) comprised a third of the workforce while the remaining two-thirds were migrants, encouraged to Australia by an intensive recruitment campaign targeting migrants from Europe and by the Government's immigration scheme following World War II. The extensive workforce employed for the scheme required townships and camps for their accommodation. Several regional townships were either created (in the case of Khancoban, Cabramurra and Talbingo) or relocated (Adaminaby and Jindabyne) and other nearby towns (Cooma, Tumut and Corryong) benefited from the activities and population of the area (Snowyhydro renewable energy website – www.snowyhydro.com.au).

In both the South Eastern Highlands and Australian Alps bioregions, the Snowy Mountains Scheme has had, and continues to have, considerable impact on the environment. These impacts are now more recognised and efforts are being made to reduce them. At Island Bend Dam, for instance, the timing and flow regime of water releases for maintenance purposes have been altered to protect the breeding habitat of the spotted tree frog (*Litoria spenceri*). As well as ensuring that water is released gradually, the timing of this work takes into consideration the frogs' breeding season (Snowyhydro renewable energy website – www.snowyhydro.com.au). In late 2000, the Victorian and NSW governments outlined a plan to restore Snowy River flows to a targeted 28% of their original levels and the plan is now beginning to be implemented (Planet Ark website – www.planetark.org).

9. Bioregional-scale conservation

The South Eastern Highlands Bioregion is managed in conservation tenures that together occupy about 726,530.55 ha or 14.86% of the bioregion. National parks and nature reserves make up the majority of this area, occupying an area of 596,638.58 ha or 12.22% of the bioregion. Twelve wilderness areas in the bioregion provide further management under the Wilderness Act 1987, with a total of 177,381.15 ha or 3.63% of the national parks or nature reserves in the bioregion. They are Bimberi, Bogong Peaks, Brogo, Budawang, Byadbo, Ettrema, Goobarragandra, Jagungal, Kanangra-Boyd, Pilot, Woila Deua and Yowrie wilderness areas. Other lands managed under the provisions of the NPW Act 1974 include karst conservation reserves, with 3,740.80 ha (or 0.08%) managed under this special tenure. Hartley and Hill End historic sites occupy 119.04 ha or 0.002% of the bioregion and land managed as state recreation areas totals 11,999.08 ha or 0.245% of the bioregion.

There are no Aboriginal areas and no regional parks in the bioregion.

In recent years, landholders have entered into 12 voluntary conservation agreements, which together occupy about 2,889.07 ha or 0.06% of the bioregion. Landholders on 96 properties also hold wildlife refuges occupying 68,776.84 ha or 1.41% of the bioregion. Updated mapping, being undertaken at the time of writing, is likely to increase the area occupied under wildlife refuges.

In addition, landholders on 141 properties have entered into property agreements under the NVC Act 1997. The conservation zones of the agreements occupy about 6,354.29 ha or 0.13% of the bioregion.

Thirteen flora reserves managed under the provisions of the Forestry Act 1916 occupy 4,654.83 ha or 0.10% of the bioregion and contribute towards biodiversity conservation. In addition, State forests managed primarily for forestry activities under the Forestry Act 1916 occupy 357,262.24 ha or 7.31% of the bioregion.

A significant proportion of the bioregion receives supplementary management under the provisions of SEPP 58 (Protecting Sydney's Water Supply). This area is 1,015,258.25 ha or 20.77% of the bioregion.

10. Subregions of the South Eastern Highlands Bioregion

(Morgan 2001)

Subregion -	Geology	Characteristic landforms	Typical soils	Vegetation
Hill End	Silurian and Devonian slates, sandstones and volcanics with numerous quartz veins. Steeply dipping, tightly folded sequence. Tertiary basalt caps with river gravels parallel to the main streams.	Plateau with hilly to mountainous edges into deep entrenched channels of Turon and Macquarie River cutting across the structural trends.	Mottled red and yellow texture contrast soils, with red earths.	Yellow box, red box and Blakely's red gum on lower areas, red stringybark, broad-leaved peppermint and white gum on hills. Brown barrel in the east. Areas of white box. River oak along main streams.
Orange	Ordovician acid volcanics and slates and phyllites and Silurian volcanics. Extensive Tertiary basalts from Canobolas and small stocks of granite. Limited limestone and serpentinite.	Low hilly to hilly plateau with Canobolas peaks rising above. Numerous volcanic features: plugs, dykes and domes in the Canobolas complex. Karst landscapes at Borenore and Molong.	Deep structures red and brown loams on basalt and fine metasediments. Mellow texture contrast soils on any slopes with a sand component in the bedrock. Alluvial loams and black clays in swampy valley floors. Limited areas of shallow organic loams at high altitude on Canobolas.	Yellow box and Blakely's red gum with red stringybark, white gum, broad-leaved peppermint across most of the plateau. Ribbon gum on lower slopes, snow gum in cold patches and high levels of Canobolas. River oak along main streams.
Bathurst	Carboniferous granite with limited areas of Tertiary basalt caps and Quaternary sands along the Macquarie River.	Rounded hills in a granite basin surrounded by steep slopes on the contact margin. Outcrops with tors near margins. - Chain of ponds streams in wide flat valley floors. - Terrace alluvium along - the Macquarie River. -	Shallow red earths on ridges, yellow texture contrast soils on all slopes and deep coarse sands in alluvium.	Apple box, yellow box, some white box and red stringybark. Ribbon gums on - lower slopes and brown barrel in the east. - Patches of black cypress pine in rocky outcrop areas. River oak along streams. -
Kanangra	Devonian sandstones with small areas of granite and fine-grained Silurian and Ordovician sediments at the edge of the Sydney Basin.	Ridges and small plateaus to 1200 m, deep valleys, swampy upper tributary floors, outcrops and tors on granite hills.	Red and yellow earths and structured loams. Well drained slopes, moderate fertility.	Grey gum, Blaxland's stringybark on lower areas, and brown barrel, mountain gum, narrow-leaved peppermint and ribbon gum on higher areas. Patches of snow gum. High diversity swamps on Boyd Plateau with carex and tea tree, sphagnum bogs in streams.
Oberon	Fine grained Silurian and Devonian slates, shales and sandstones with Ordovician acid volcanics. Basalt caps and flows on highest crests.	Rounded and stepped hills of plateau, dendritic drainage pattern parallels basalts on crests and ridges.	Red and yellow texture contrast soils on slopes, well-structured deep red loams on basalt. Moderately fertile soils but cold environment.	Narrow-leaved peppermint, mountain gum and some snow gum on high areas. Apple box, yellow box, ribbon gum and Blakely's red gum in the west.

10. Subregions of the South Eastern Highlands Bioregion *CONTINUED*

Subregion -	Geology	Characteristic landforms	Typical soils	Vegetation
Crookwell	Fine grained Ordovician and Silurian sedimentary rocks, with some granites. Tertiary basalts with buried river gravels along ridges well above present streams.	Hilly, with some rugged areas and deep valleys. Hill tops may be small plateaus or capped by basalt and showing inverted relief. -	Red and yellow texture contrast soils, thin and stony on steep slopes. Stony brown structured loams on basalts.	Apple box, mountain gum with Blakely's red gum and yellow box. Red stringybark, - white box, broad-leaved peppermint and - mottled gum on stony ridges in the north. Small areas of Argyle apple. -
Bungonia	Primarily fine-grained Palaeozoic sedimentary and meta-sedimentary rocks, with minor areas of acid volcanics and limestone. Areas of Tertiary river terrestrial sediments and low sandsheets in the south with very limited basalt.	Distinct plateau with very steep, deep margins on the Great Escarpment dropping into the Shoalhaven River. Strong linear ridges on resistant sandstones and volcanics, wide valleys with some cold air - drainage and inverted - tree lines. -	Mostly yellow texture contrast soils some with harsh clay subsoils. Shallow structured organic loams on limestone and basalt, deep siliceous sands and clayey sands on - Tertiary sediments. -	Mottled gum, broad-leaved peppermint, white gum, red stringybark and black ash - forests and woodlands. - Snow gum with and snow grass in cold pockets. Black she-oak common as - understorey and in regeneration areas. - Limited distribution of argyle apple. -
Murrumbateman	Fine-grained Palaeozoic sedimentary and meta-sedimentary rocks, with minor areas of coarse acid volcanics. Tertiary alluvial terraces along main streams.	Undulating plateau with rounded hills and peaks, entrenched meandering streams with chain of ponds tributaries.	Mottled yellow and brown texture contrast soils with strongly bleached topsoils. Dark organic loams and clay loams on valley floors. Saline patches present.	Blakely's red gum, yellow box, on lower slopes, red stringybark, bundy and white gum on ridges. Areas of apple box, and mottled gum. Limited swampy flats and valley floor grasslands.
Western Fall	Silurian and Devonian acid intrusives, fine-grained Palaeozoic sedimentary and meta-sedimentary rocks and areas of granite.	Rugged hills, with small plateau areas. Steep stony slopes and string structural control on ridge lines.	Red earths and red texture contrast soils. Typically thin and stony on slopes, thickening on footslopes, and becoming yellow and harsh on valley floors.	Narrow-leaved peppermint, red stringybark, ribbon gum, and mountain gum open forests.
Monaro	Block faulted ranges and closed lake basins in Silurian and Devonian acid fine grained sedimentary and metamorphic rocks with some granites. Extensive areas of thin Tertiary basalt flows over lake and river sediments.	Sloping plateau rising from 600 to 1300 m north to south. Structural ridges of more resistant rock. Stepped plains on basalt with intervening low areas of granite or sedimentary rocks. Numerous shallow lakes and swamps, a few permanent many are closed basins and periodically dry. Area is in rainshadow with rainfall 450-700mm.	Harsh yellow texture contrast soils in general. Shallow red brown to black stony loams on basalt.	Snow gum, ribbon gum, candle-bark gum, broad-leaved peppermint and mountain gum open woodlands with Kangaroo grass understorey. White gum, mottled gum on hills. Brown barrel and black ash forests in east with west facing patches of dwarf casuarina heathland. Extensive grasslands of snow grass, spear grass and wallaby grass on the driest plains with clumps of snow gum amongst rocky outcrops.

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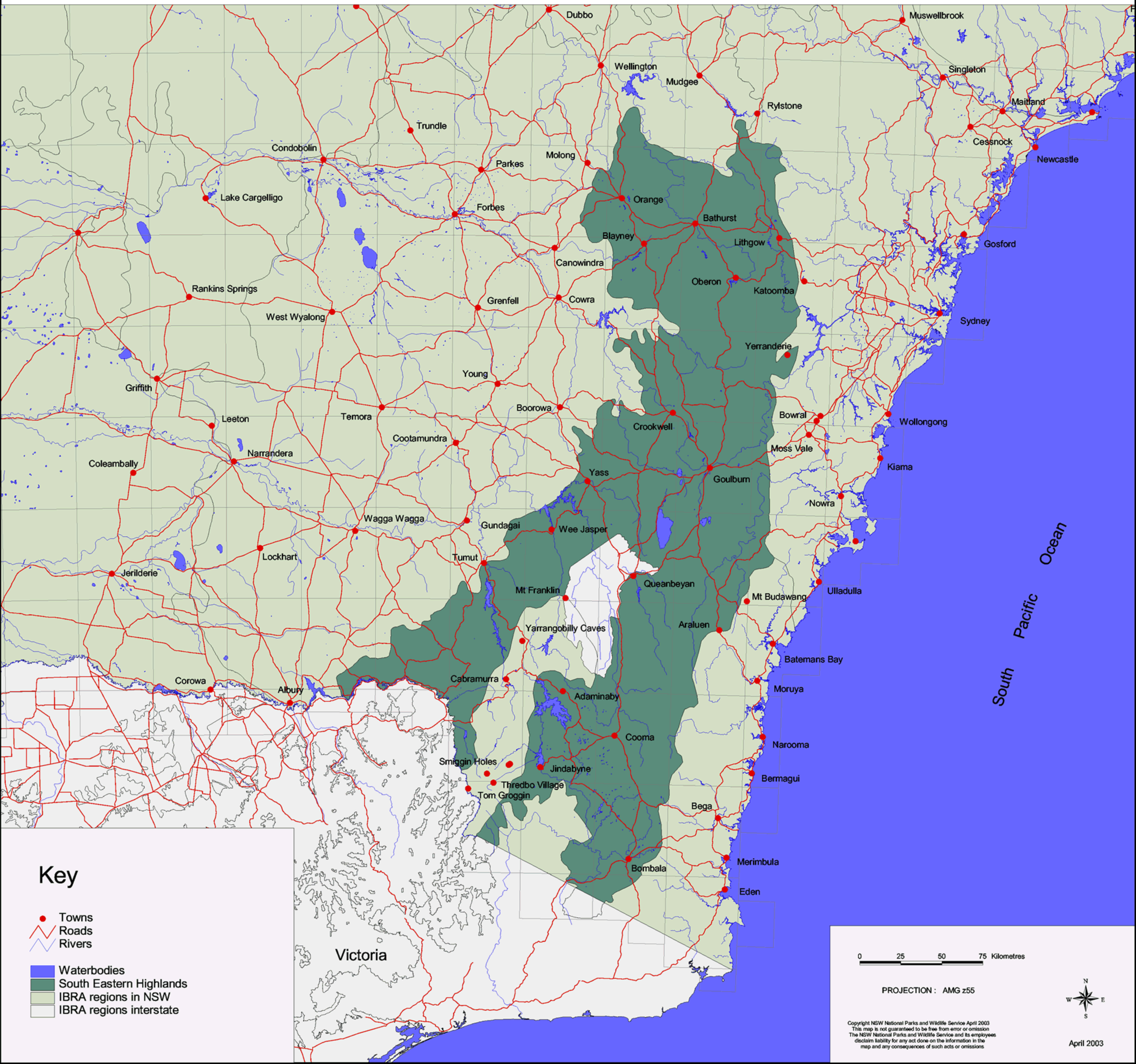
South Eastern Highlands Biogeographic Region (IBRA) - Location



Key

- Towns
- Roads
- Rivers
- Waterbodies
- South Eastern Highlands
- IBRA regions in NSW
- IBRA regions interstate

0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

South Eastern Highlands Biogeographic Region (IBRA) - Rivers

Key

- South Eastern Highlands BR boundary
- IBRA regions in NSW
- Rivers
- Catchment Management Board areas
- Waterbodies

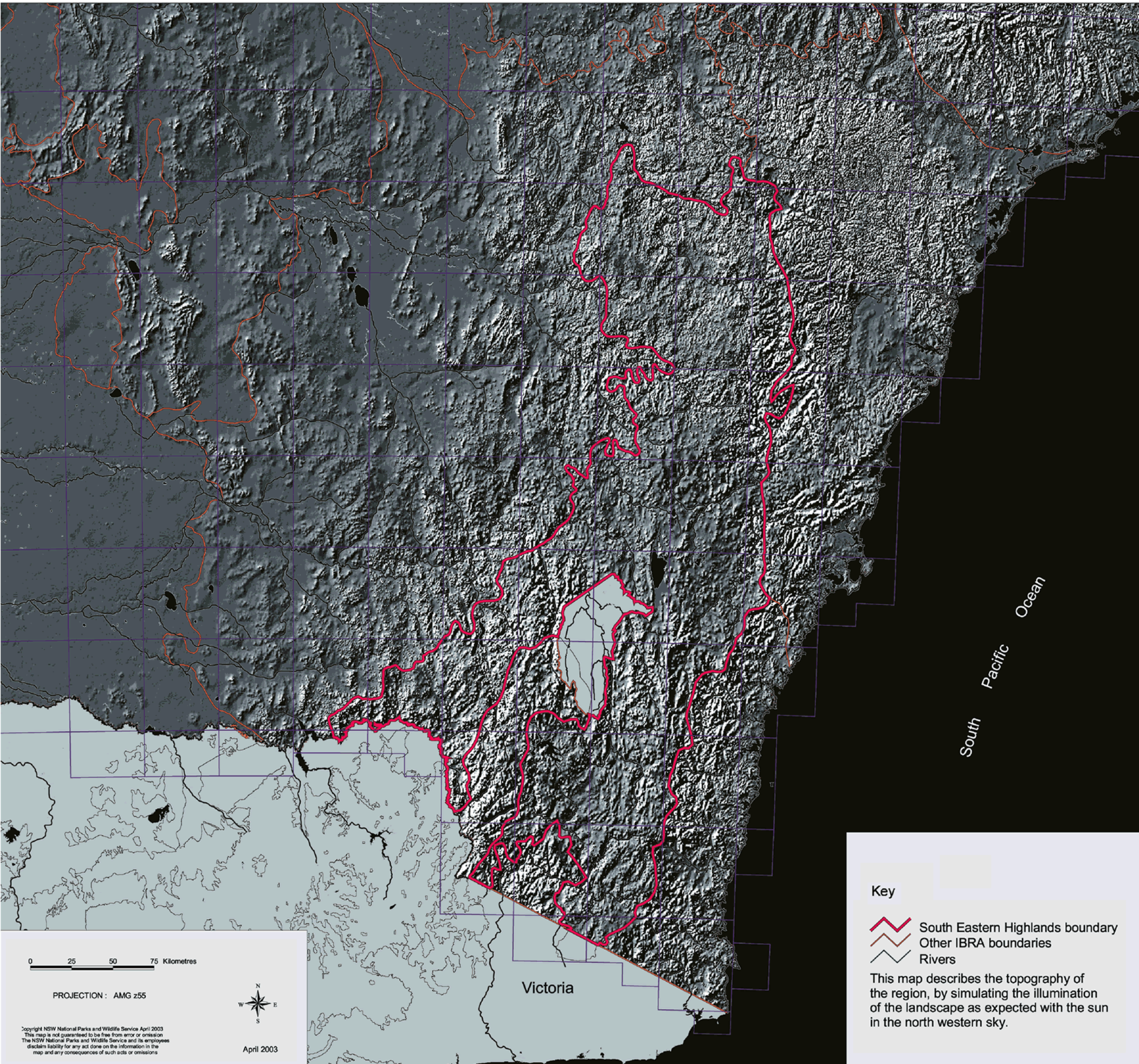
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

South Eastern Highlands Biogeographic Region (IBRA) - Topography



0 25 50 75 Kilometres

PROJECTION : AMG z55

N
W E
S

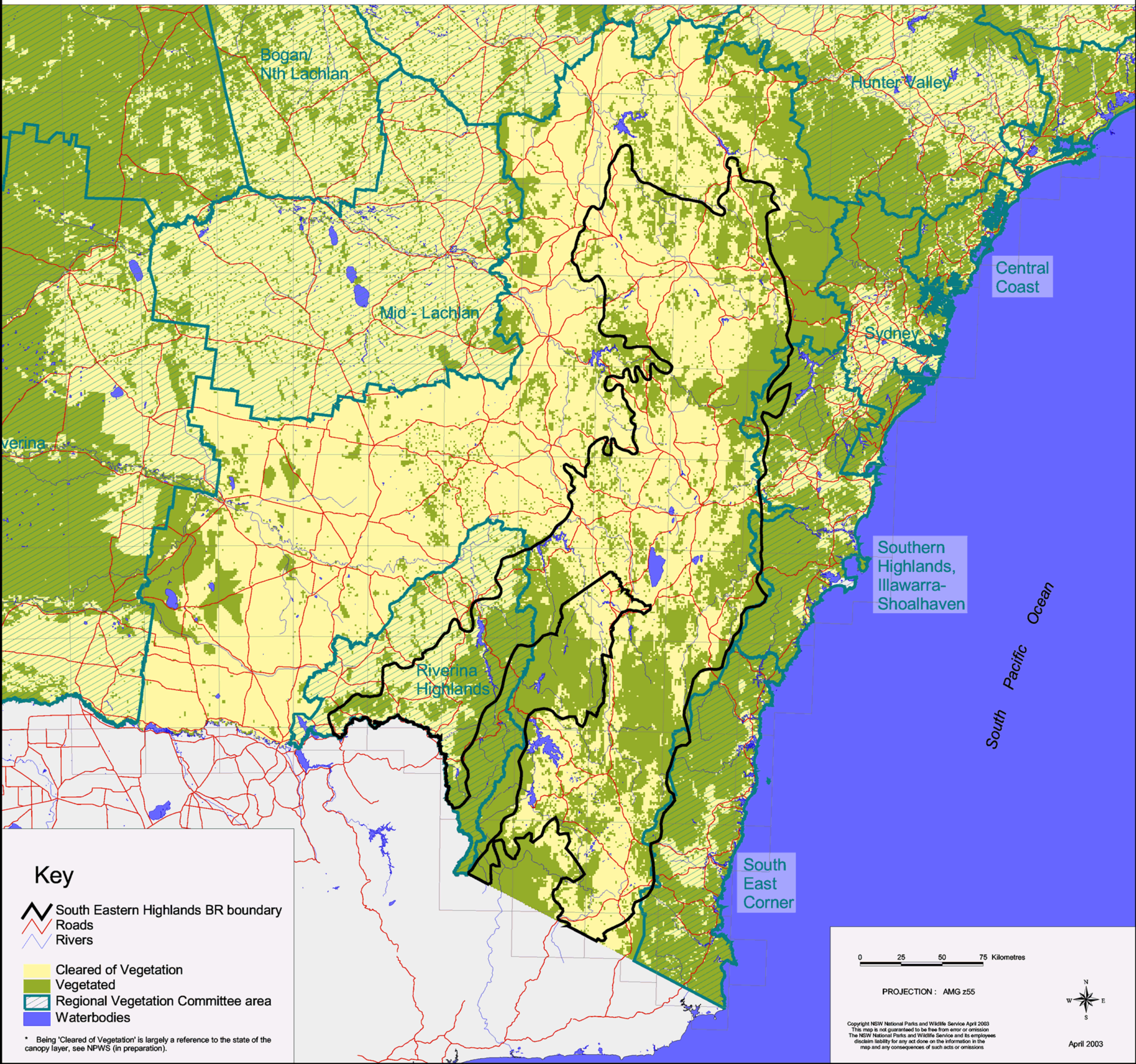
April 2003

Key

South Eastern Highlands boundary
Other IBRA boundaries
Rivers

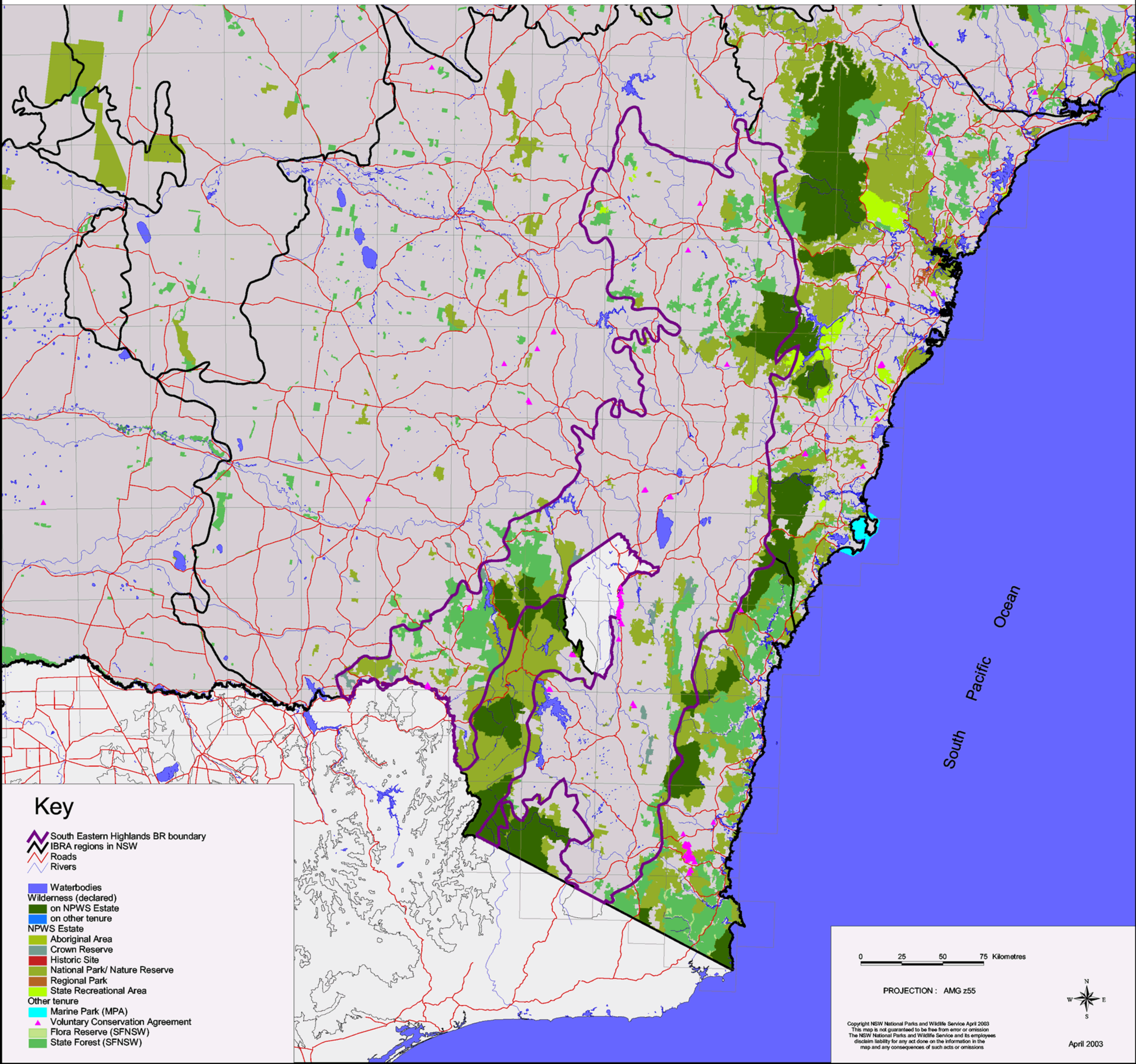
This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

South Eastern Highlands Biogeographic Region (IBRA) - Vegetation



April 2003

South Eastern Highlands Biogeographic Region (IBRA) - Tenure/Reserves



Key

- South Eastern Highlands BR boundary
- IBRA regions in NSW
- Roads
- Rivers
- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

South Eastern Highlands Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)

Key

Subregions (IBRA)
South Eastern Highlands

IBRA regions in NSW
IBRA regions interstate

Landscapes

609 610 613 614 616 625 631 635 636 637 640 686 689 690 691 698 699 700 704 708 712 714 718 722 725 726 728 729 730 731 736 750 761 765 768 770 771 773 774 775 776 778 779 781 784 785 786 788 789
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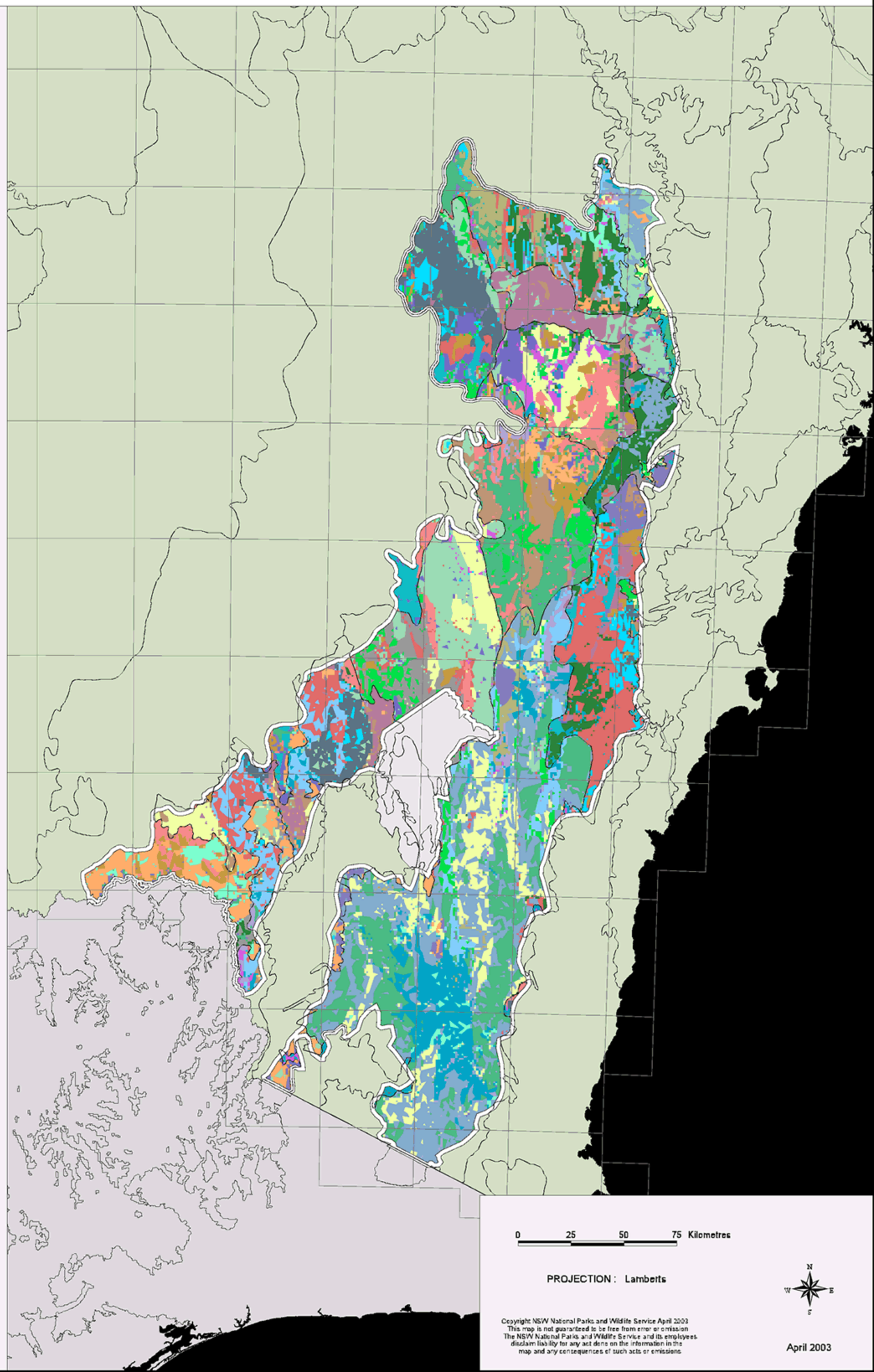
* A description of each landscape, identified by these landscape codes, is available in 'State Conservation Monitoring Project - Monitoring NSW Environments' (NPWS, in preparation)



April 2003

CHAPTER 17

The Australian Alps Bioregion

1. Location

Alpine habitats have a very limited extent in Australia, with a total coverage of 793,818 ha, 54.02% of which is in NSW. This bioregion is the smallest in NSW, occupying 0.54% of the state, and is one of the smallest bioregions in Australia. The bioregion spans 428,832 ha of NSW, with most of the remainder in Victoria (323,549 ha) and a small proportion (40,710 ha) in the southwest of the ACT. In NSW, the bioregion is entirely surrounded by the South Eastern Highlands Bioregion. In Victoria, it becomes discontinuous towards Mt Buffalo, with outlying patches.

Part of the Australian Alps Bioregion lies in the Murray-Darling Basin, encompassing the headwaters of the Murray, Murrumbidgee and Snowy rivers and traversed by the Tumut and Yarrangobilly rivers.

NSW towns in the bioregion include Cabramurra, the highest town in Australia, and the ski resort towns of Guthega, Perisher Valley, Smiggins Holes and Thredbo Village. Other notable areas include Yarrangobilly Caves, and Mts Kosciuszko, Jagungal and Tom Groggin.

2. Climate

Although dominated by a montane climate, with no dry season and a mild summer (Stern *et al.* 2000), the Australian Alps Bioregion contains a patch of true alpine climate. This area, in the southwest of the bioregion presents the only example of alpine and sub-alpine climate in NSW, characterised by no dry season and a cool summer.

The extreme climatic gradient across the alpine ranges is reflected in the soil and vegetation that pass from lowland eucalypt forest on texture contrast soils to alpine herbfield on organic uniform soils at the highest elevations. Above 1,400 m, snow may persist for 4 to 6 months and frost can occur throughout the year. The northeastern tip of the bioregion is representative of the temperate zone, which prevails in the New England Tableland, South Eastern Highlands and Sydney Basin bioregions where there is a warm summer and no dry season (Stern *et al.* 2000).

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
3 – 12°C	-7 – 0.4°C	15.9 – 29.5°C	606 – 2,344mm	44 – 126mm	63 – 295mm

3. Topography

The Australian Alps Bioregion constitutes the highest section of the Great Dividing Range, and contains Australia's highest mountain, Mt Kosciuszko (2,228 m). The landscape is characterised by peaked ranges, and broad, forested valleys, and is the only true alpine environment in NSW.

4. Geology and geomorphology

The alpine area comprises granites that have formed faulted, stepped ranges at the point where the South Eastern Highlands in NSW turn west into Victoria. More recent volcanic activity produced basalts and, in the Pleistocene, the cold climate superimposed glacial features on the landscape.

The bioregion was the only part of the mainland to have been affected by Pleistocene glaciation and contains a variety of unique glacial and periglacial landforms above 1,100m altitude. Evidence of glaciation has been obtained from pollen preserved in alpine and subalpine lakes and bogs.

The original uplift of the steep seaward scarp of the Great Divide is attributed to the intersection of two coastal uplift zones created by the opening of the Tasman Sea and Southern Ocean during the break up of Gondwana. Elsewhere, more recent volcanic activity in the Tertiary produced the basalts found in the Cabramurra-Kiandra area.

The upper surfaces of the granite blocks have a low relief and form an environment of high plains where cold air drainage has a major impact on vegetation patterns. Stream patterns have also been affected by the geology. Meandering systems on the high plains become deeply incised gorges with waterfalls and cascades as the streams cross the fault block margins. Larger streams follow major fault lines such as the Thredbo-Crackenback valley.

5. Geodiversity

Important features include the following:

- the bioregion contains Australia's highest mountain (Mt Kosciuszko 2,228m) and is the only part of the mainland to boast a suite of Pleistocene glacial and periglacial landscape features;
- there are well-documented karst landforms at Yarrangobilly and Cooleman;
- there are pseudokarst landforms in alpine block streams and boulder piles;
- the sub-basalt sediments at Kiandra are exposed by mining and contain important leaf fossils preserved in lignite;
- mining heritage items relating to sluicing and dredging operations are present; and
- construction works of the Snowy Mountains Hydro-Electric Authority, which began in 1949, are also heritage items in the context of engineering geology.

6. Soils

The soils of this bioregion reflect the extreme climatic gradient across the ranges. The lowlands consist mainly of texture contrast soils, grading to uniform, organic soils and peats at the highest elevations.

Photo: D. Perryman

7. Biodiversity

7.1 Plant communities

Both altitude and rainfall influence the vegetation communities of the Australian Alps Bioregion. There are four main physiographic elements to the bioregion, these being alpine, sub-alpine, montane and tableland areas (NSW NPWS 1988).

7.1.1 Alpine (areas above 1,850 m)

Tall alpine herbfield and heathland communities dominate the high alpine areas of the bioregion (Costin *et al.* 1979). Other communities such as sod tussock grassland, short alpine herbfield, feldmark (unique species or communities of prostrate plants that occur in remote alpine regions), bog and fen can occur where the effects of temperature, aspect, drainage and exposure impede the growth of tall herbfields (NSW NPWS 1988).

The highly organic soils of the alpine areas support about 200 plant species (Mitchell 2002). *Brachycombe nivalis–Danthonia alpicola* and *Poa* sp.–*Celmisis* sp. associations dominate the tall alpine herbfield communities (NSW NPWS 1988). Species such as the silver snow daisy (*Celmisia* sp.), ribbony grass (*Chionochloa frigida*), mountain celery (*Aciphylla glacialis*) and white purslane (*Neopaxia australasica*) also occur here (Mitchell 2002).

Tall herbfields on the flat or gentle sloping valley floors support sod tussock grasslands and several other inter-tussock herbs, especially Asteraceae species, including some that are rare and endemic (NSW NPWS 1988). Prickly snow grass (*Poa costiniana*) and alpine wallaby grass (*Danthonia nudiflora*) occur in tussock grasslands (Mitchell 2002).

Plantago sp. (*Neopaxia australasica*) associations dominate the short alpine herbfield communities that grow in areas below snowdrifts where cold snow water hampers the growth of the taller herbfield species (NSW NPWS 1988). Several other significant species comprise the community, including *Caltha introloba*, which has the unique characteristic of commencing flowering beneath the snow, and other low-growing species such as *Dichosciadium ranunculaceum, Brachycome stolonifera, Diplaspis hydrocotyle* and *Parantennaria uniceps* (NSW NPWS 1988).

Valleys and raised bogs support sphagnum, sedge (*Carex gaudichaudiana*) and heath (*Epacris glacialis*). The unique feldmark communities of the alpine region support ground-hugging alpine species such as coral heath (*Epacris microphylla*), eye-bright (*Euphrasia collina*), silver ewartia (*Ewartia nubigena*) and felted buttercup (*Ranunculus muelleri*), which are found on extremely stony and exposed snow patch sites (Mitchell 2002).

A high proportion of alpine species are endemic and all have restricted ranges (Mitchell 2002).

7.1.2 Subalpine (areas between 1,400 and 1,850 m)

Eucalyptus pauciflora–E. pauciflora ssp. niphophila (snow gum) woodland dominates the sub-alpine areas of the bioregion, interspersed with extensive open grasslands and heath (Mitchell 2002). About 80% of these woodlands have regenerated following severe bushfires over the last 50 years. A dense understorey of shrubs lies beneath the tree canopy, including *Oxylobium ellipticum–Podocarpus lawrencii* associations, with *Bossiaea foliosa* species (NSW NPWS 1988). These species form both the tall, shrubby understorey and, on exposed sites, dense heaths. A short heath of *Kunzea muelleri–Epacris* spp. grows in place of the tall heath on sites with poor drainage (NSW NPWS 1988).

Cold air drainage into the valleys, known as frost hollows, prevents trees growing in the sod tussock grasslands on the valley floors where *Poa* sp.–*Danthonia nudiflora* associations dominate (NSW NPWS 1988). Bogs and fens develop here in the valleys where the water tables rise up to or above the ground. Fen communities are dominated by *Carex* species and are limited by permanent watercourses or are part of bog communities, which are usually defined by *Sphagnum* species.

7.1.3 Montane (areas between 1,100 and 1,400 m)

The montane areas of the bioregion are dominated by forests and woodlands of stringybarks and gums which grow in sequence from swamp gums (*Eucalyptus ovata*), peppermint forests (narrow-leaved peppermint *E. radiata*) and blue gums (*E. globulus* ssp. *bicostata*) on the lower slopes, to mountain gum (*E. dalrympleana*), candlebark (*E. rubida*), ribbon gum (*E. viminalis*) and alpine ash (*E. delegatensis*) which eventually give way with altitude to pure stands of snow gum which grow directly below the treeline (Costin *et al.* 1979).

These montane forests and woodlands are mainly associated with snow gums, including *E. pauciflora*, *E. dalrympleana*, *E. rubida*, *E. viminalis*, and *E. stellulata*. *E. delegatensis* dominates the wetter areas with southerly and southeasterly aspects (NSW NPWS 1988). This wet sclerophyll forest has an understorey of species, including *Bossiaea foliosa*, that are similar to those in sub-alpine areas. *E. globulus* ssp. *bicostata*, *E. glaucescens* and *E. fastigata* occur in more sheltered areas as dominant trees or are co-dominant with other species or associations. Isolated occurrences have been recorded for *E. kybeanensis*, *E. chapmaniana*, *Acacia dallachiana* and *Atherosperma moschatum* (NSW NPWS 1988). The more westerly aspects comprise narrow-leaved peppermint (*E. radiata*)–ribbon gum (*E. viminalis*)–candlebark (*E. rubida*) associations as dominants. Sheltered areas with easterly aspects are dominated by brown barrel (*E. fastigata*)–alpine ash (*E. delegatensis*) associations (NSW NPWS 1988) and black sallee (*E. stellulata*) lines the streams on the high plains (Mitchell 2002).

High plains grasslands are dominated by snow grass (*Poa* sp.) with patches of heath that include leafy bossiaea (*Bossiaea foliosa*), yellow kunzea (*Kunzea muelleri*), royal grevillea (*Grevillea victoriae*), alpine pepper (*Tasmannia xerophila*), small-fruit hakea (*Hakea microcarpa*) and mountain shaggy pea (*Oxylobium alpestre*). Sphagnum bogs (*Sphagnum cristatum*) with candle heath (*Richea continentis*) and swamp heath (*Epacris paludosa*) occur at the head of most creeks (Mitchell 2002).

7.1.4 Tableland (areas below 1,100 m)

Savannah woodlands are common in the tableland areas of the Australian Alps Bioregion and are dominated by *E. melliodora–E. blakelyi* and *E. viminalis–E. rubida* associations (NSW NPWS 1988). Mixed eucalypt forest is found at the lowest elevations (Mitchell 2002). On dry aspects or well-drained granites, the forests are typified by red stringybark (*E. macrorhyncha*), white gum (*E. rossii*), broad-leaved peppermint (*E. dives*), candlebark (*E. rubida*), and brittle gum (*E. mannifera*) with a diverse understorey of shrubs and grasses (Mitchell 2002). On sedimentary rocks or in moist aspects and higher rainfall areas, more common tree species include alpine ash (*E. delegatensis*), mountain gum (*E. dalrympleana*), narrow-leaved peppermint (*E. radiata*), manna gum (*E. viminalis*) and brown barrel (*E. fastigata*) (Mitchell 2002). The peppermints (broad-leaved *E. dives* and narrow-leaved *E. radiata*) are dominant on exposed sites, while *E. dalrympleana*, *E. pauciflora* and *E. viminalis* occur at higher altitudes in moister areas (NSW NPWS 1988). Moist gullies support soft tree ferns (*Dicksonia antartica*), blackwood (*Acacia melanoxylon*), southern sassafras (*Atherosperma moschatum*) and hazel pomaderris (*Pomaderris aspera*).

7.2 Significant flora

Within the alpine areas of the bioregion there are about 30 exclusively alpine species and 21 locally endemic species (NSW NPWS 1988). Furthermore, 61 species are singularly representative of their genus and 20 are singular representatives of their family that grows above the treeline.

Feldmarks cover less than one per cent of alpine areas (NSW NPWS 1988). Cold feldmarks are found in sheltered areas of high mountain saddles, while wind-swept feldmarks occur in more exposed locations at higher altitudes on the windward side of saddles. Feldmark communities support *Coprosma pumila–Colobanthus* sp. and *Epacris microphylla–Chionohebe densifolia* associations.

7.3 Significant fauna

The record of species such as the tiger quoll (*Dasyurus maculatus*) and koala (*Phascolarctos cinereus*) in Kosciuszko National Park is significant, because these species are not recorded frequently in NSW and their ranges in the park appear to be diminishing (NSW NPWS 1988). The broad-toothed rat (*Mastacomys fuscus*) was once widespread throughout southeastern Australia and is now restricted to certain areas of the Australian Alps Bioregion within Kosciuszko National Park (NSW NPWS 1988).

The eastern or Tasmanian bettong (*Bettongia gaimardi*) has been recorded in the Australian Alps Bioregion since European settlement although it has not been seen for many years and is now considered to be extinct on the Australian mainland. Like the bettong, the eastern quoll (*Dasyurus viverrinus*) has been recorded in the bioregion and unconfirmed reports were received occasionally until 1970, the date of the last report (NSW NPWS 1988).

Of the 202 bird species recorded in Kosciuszko National Park, two are locally extinct. The orange-bellied parrot (*Neophema chrysogaster*), which is now extinct in the bioregion, was known from a single specimen collected in Thredbo in 1917. The Australian bustard (*Ardeotis australis*) is also locally extinct, having been recorded in the park in 1896, and it is now known only from the far northwest of NSW (NSW NPWS 1988)

Other species have not been recorded in Kosciuszko National Park for many years. These include the masked owl (*Tyto novaehollandiae*, last recorded in 1896), the banded plover (*Vanellus tricolour*, in 1946) and the southern whiteface (*Aphelocephala leucopsis*, also in 1946) although they may still be present in small numbers (NSW NPWS 1988). Some species regarded as uncommon or scarce in NSW have been seen in the Park. These include the pink robin (*Petroica rodinogaster*), the black-eared cuckoo (*Chrysococcyx osculans*) and the blue-winged parrot (*Neophema chrysostoma*).

The variety of altitudes in the bioregion gives rise to altitudinal migration throughout the year. Birds such as the pipit (*Anthus novaeseelandiae*), nankeen kestrel (*Falco cenchroides*) and the Australian magpie (*Gymnorhina tibicen*) occupy the treeless alpine areas during summer, retreating to lower elevations in autumn. Some species, however, are not discouraged by the harsh winter climate of the higher altitudes; the gang-gang cockatoo (*Callocephalon fimbriatum*) inhabits the sub-alpine snow gums even in winter (NSW NPWS 1988).

As no Australian bird species are truly alpine, and none is endemic to the bioregion, the Australian Alps Bioregion has a low bird species diversity, the frequently sighted species generally living in the woodlands adjacent to the alpine grass and herbfields. Declines in species such as the gang-gang cockatoo and the flame robin, which occupy higher altitudes, may reflect the warmer weather of the last few decades although this cannot be confirmed without further studies. However this loss of upland species and a contraction of grassland is a likely future scenario if the trend towards higher temperatures continues.

Reptiles and frogs in the Australian Alps Bioregion display a surprising degree of diversity considering its harsh climate. There are reported to be 31 species of reptiles in Kosciuszko National Park. One of these, the alpine water skink (*Sphenomorhus koscuiskoi*), is restricted to habitats higher than 1,000 m in the southern tablelands and so its range is almost entirely restricted to the Park. There are 7 snakes known to occur in the Park although some species are rarely seen. Of the lizards known to occur in the Park, some have not been recorded for many years (NSW NPWS 1988). There are reported to be 11 species of frogs in the Park, including the unusual corroboree frog (*Pseudophryne corroboree*), which can be identified by its distinctive black and yellow markings and is found in the sphagnum bogs of the alpine areas. The species is known to have 2 forms, a northern form, which occurs mainly in the ACT, and a southern form, which may be endemic to Kosciuszko National Park.

The rivers in the east of Kosciuszko National Park support species of migratory eels and two freshwater fish species from the galaxiid family, while species of perch, gudgeon, Murray cod and possibly galaxiids occur in the western rivers. Brown, rainbow and brook trout, as well as Atlantic salmon and redfin, have been introduced to the rivers in the bioregion (NSW NPWS 1988).

7.4 Significant wetlands

All of the wetlands of the bioregion are considered to be in near pristine condition despite problems with feral animals and impacts from tourism activities. No decline in status is evident, largely because they have been protected within Kosciuszko National Park.

Blue Lake is the only dimictic lake in mainland Australia, meaning its thermal layers are mixed completely twice each year. Such glacial lakes are significant because they are low in nutrients and are completely iced over for half the year, providing key habitat for species of invertebrate fauna not found elsewhere (ANCA 1996).

Kosciuszko alpine fens, bogs and lakes are the only alpine wetlands in NSW. Alpine plant succession in the area has been studied since the exclusion of cattle grazing in 1958 (ANCA 1996). The sphagnum bogs of these wetlands are probably suitable breeding habitat for the southern corroboree frog.

Rennex Gap lies at the inside edge of the sub-alpine snow gum woodland of Mt Kosciuszko and is considered to be a good example of upland peatland. The area provides fire and vegetation histories close to the Pleistocene ice cap (ANCA 1996). Snowgum Flat, like Rennex Gap, is also a good example of upland peatland and is representative of low altitude sub-alpine bogs characteristic of the southern end of Kosciuszko National Park (ANCA 1996).

8. Regional history

8.1 Aboriginal occupation

The Australian Alps Bioregion was the traditional home of two Aboriginal groups. The Walgal people occupied the northern part of the bioregion near Kiandra in what is now Kosciuszko National Park, while the Ngarigo people lived in the region around the highlands (HO and DUAP 1996).

Many of the Aboriginal groups in the southern part of NSW gathered in the Australian Alps Bioregion in the summer months on an annual pilgrimage to the Bogong and Snowy Mountains. Here, the men participated in a feast of bogong moths (*Agrotis infusa*) that were to be found in abundance on the rocky outcrops of the mountains (HO and DUAP 1996).

The traditional lifestyles of the local Aborigines, including the annual Bogong moth feast, were disrupted from the late 1820s when graziers brought stock into the area and are considered to have ceased by 1850 in this and nearby bioregions (HO and DUAP 1996). Diseases brought in by the new settlers infected Aboriginal communities, diminishing their population in this bioregion and across NSW (HO and DUAP 1996).

8.2 European occupation

Due to the pressure for grazing land, squatters with cattle occupied the Australian Alps Bioregion and surrounds by the 1820s, moving outside the "limits of location" set for the colony at the time (NSW NPWS 1991). Almost all areas, from the base of the Alps to the coast, were already occupied by squatters on land suitable for grazing both sheep and cattle (HO and DUAP 1996). It was not until the 1860s that the settlers realised the potential of alpine grazing and stock were moved up into the alpine areas during summer and returned to the valleys in autumn. Sometimes this practice ended in disaster when winter set in early (HO and DUAP 1996), resulting in loss of both stock and men (NSW NPWS 1991). This practice led to the introduction of snow leases, which ran from 1889 until 1957 when their impact on the vulnerable alpine environment was recognised and the leases were abolished.

By then, the stock routes for cattle and sheep were well-trodden and the stockmen's huts which can be found along the route are now important heritage items in the area (HO and DUAP 1996). In 1859, the discovery of gold at Kiandra, northeast of Cabramurra, rapidly stimulated a gold rush. Many miners arrived in Kiandra in the winter of 1860 in readiness to start mining in the spring. It was at about this time that skiing was introduced at Kiandra by gold miners from northern Europe (NSW NPWS 1991). Of course, skiing has remained an important part of the social history of the bioregion and a popular tourist drawcard to the present day. During its peak, the Kiandra goldfield supported 10,000 people, including several hundred Chinese miners. The Kiandra goldrush lasted until early 1861 at which time miners moved on to the next prospering fields (NSW NPWS 1991). The Chinese miners brought with them their traditional ways, using yokes to carry equipment through the harsh alpine country. Several remained in the bioregion, some establishing stores which lasted until the 1900s.

While gold rushes moved around the countryside with each new discovery, small-scale mining continued in the Australian Alps Bioregion from 1905-1930, becoming more profitable with the introduction of hydraulic sluicing and dredging (NSW NPWS 1991). Remnants of gold, silver and tin mining occur in what is now the southern end of Kosciuszko National Park.

The Snowy Mountains Hydro-Electric Scheme altered the bioregion considerably from 1949, both physically and demographically. Construction of the scheme began at Adaminaby in the South Eastern Highlands Bioregion (Department of Immigration website – http://www.immi.gov.au/). Several towns in the Australian Alps Bioregion, for example Khancoban and Cabramurra, owe their existence to the scheme, which brought around 100,000 people to the area over a 25-year period (Snowy Mountains Hydro-Electric Scheme website – http://www.snowyhydro.com.au/).

Kosciuszko National Park, which occupies most of the bioregion, was gazetted in 1967 but had been recognised under the Kosciuszko State Park Act since 1944. In 1977 the United Nations Educational, Scientific and Cultural Organisation (UNESCO) recognised Kosciuszko National Park under its *Man and the Biosphere* program as an "International Biosphere Reserve", one of only 2 in NSW (UNESCO website – www2.unesco.org/mab/br/brdir/directory/biores.asp).

Land use is restricted to sheep and cattle in the rugged areas (HO and DUAP 1996) and has resulted in an important wool, mutton and beef industry in the bioregion and surrounds. Dairying was important for a time in the 1890s but this lasted only until the 1920s. Although the region was subject to some drought and low wool prices in the 1840s and again in the 1880s, the great drought of the late 1890s did not affect the bioregion. Rabbits were not such a problem here as in the west.

9. Bioregional-scale conservation

In NSW, the Australian Alps Bioregion receives the highest proportion of conservation-oriented management of any of the NSW bioregions, constituting about 90.34% of the bioregion, or 386,744.96 ha. While the area under some form of conservation-oriented management is large, the range of mechanisms used is relatively small.

Most conservation occurs in national parks and nature reserves. Kosciuszko National Park occupies a large proportion (87.18%) of the bioregion, while the remaining reserved areas within the bioregion consist of Bimberi, Scabby Range and Yaouk Nature Reserves. Almost one-third of the area of national parks and nature reserves are also managed under the Wilderness Act 1987, comprising the Bimberi, Bogong Peaks, Goobarragandra, Jagungal and Pilot wilderness areas which occupy approximately 32.80% of the bioregion.

Of the other conservation mechanisms listed in the NPW Act 1974, only the voluntary conservation agreement and wildlife refuge provisions are utilised. There are no historic sites, no Aboriginal areas, no state recreation areas and no regional parks in the bioregion.

One voluntary conservation agreement has been entered into by a landholder within the bioregion. This agreement occupies 90.95 ha or 0.02% of the bioregion. One wildlife refuge occupying 217.35 ha or 0.05% of the bioregion is held by another landholder in the bioregion. Two more wildlife refuges are likely to be added in the near future. There is also one property agreement (NVC Act 1997). The conservation zone of this property agreement occupies an area of 120.23 ha or 0.03% of the bioregion. Thus the total area of land managed in the Australian Alps under private land conservation legislation constitutes 0.10% of the bioregion, or 428.53 ha.

Some land is managed under the Forestry Act 1916. While there are no formal or informal reserves (Forest Management Zones 1, 2 and 3a) in the bioregion there are 2 state forests, Maragle and Ingebirah, which are managed for a range of forestry activities including timber production and forest management. Together these occupy about 2,486 ha or 0.58% of the bioregion.

10. The sub-region of the Australian Alps Bioregion

The entire NSW portion of the Australian Alps Bioregion has been delineated as a sub-region.

(Morgan 2001)

Geology	Characteristic landforms	Typical soils	Vegetation
Block-faulted granites and Palaeozoic metamorphic rocks. Small areas of Tertiary basalt with buried river gravels and lake sediments. Quaternary glacial landforms and sediments above 1,800 m, more extensive periglacial features above 1,200 m.	Low-relief high plains with steep margins and slopes and fault aligned river valleys with deep gorges and waterfalls. Relic cirque glaciers, blockstreams and periglacial solifluction lobes in highest regions.	Soils change with altitude. At lower levels in forests texture contrast soils are the norm. In the sub-alpine snow gum areas deep gradational soils with moderate amounts of organic matter are common. Above the tree line, wet, alpine humus soils with abundant organic matter are widespread. Steep slopes have stonier, shallow profiles.	Vegetation changes with altitude, aspect, cold air drainage and soil saturation. Low elevations with dry aspects carry red stringybark, white gum, broad-leaved peppermint, candlebark and brittle gum. Moist sites have alpine ash, mountain gum, narrow-leaved peppermint, manna gum and brown barrel, with tree ferns, blackwood and sassafras in gullies. Between 1,000 and 1,500 m alpine ash and mountain gum dominate and abruptly change to sub-alpine snow gum woodlands, heath, grasslands and bogs between 1,500 and 1,800 m. Common species include snow grasses, leafy bossiaea, yellow kunzea, alpine pepper and sphagnum bogs, with candle heath and swamp heath. Alpine herbfield and rare feldmark communities are found above the tree line at 1,800 m. Common species include prickly snow grass, alpine wallaby grass, silver snow daisy, ribbony grass, white purslane, eye-brights, gentians and buttercups. Most alpine species have a limited range.

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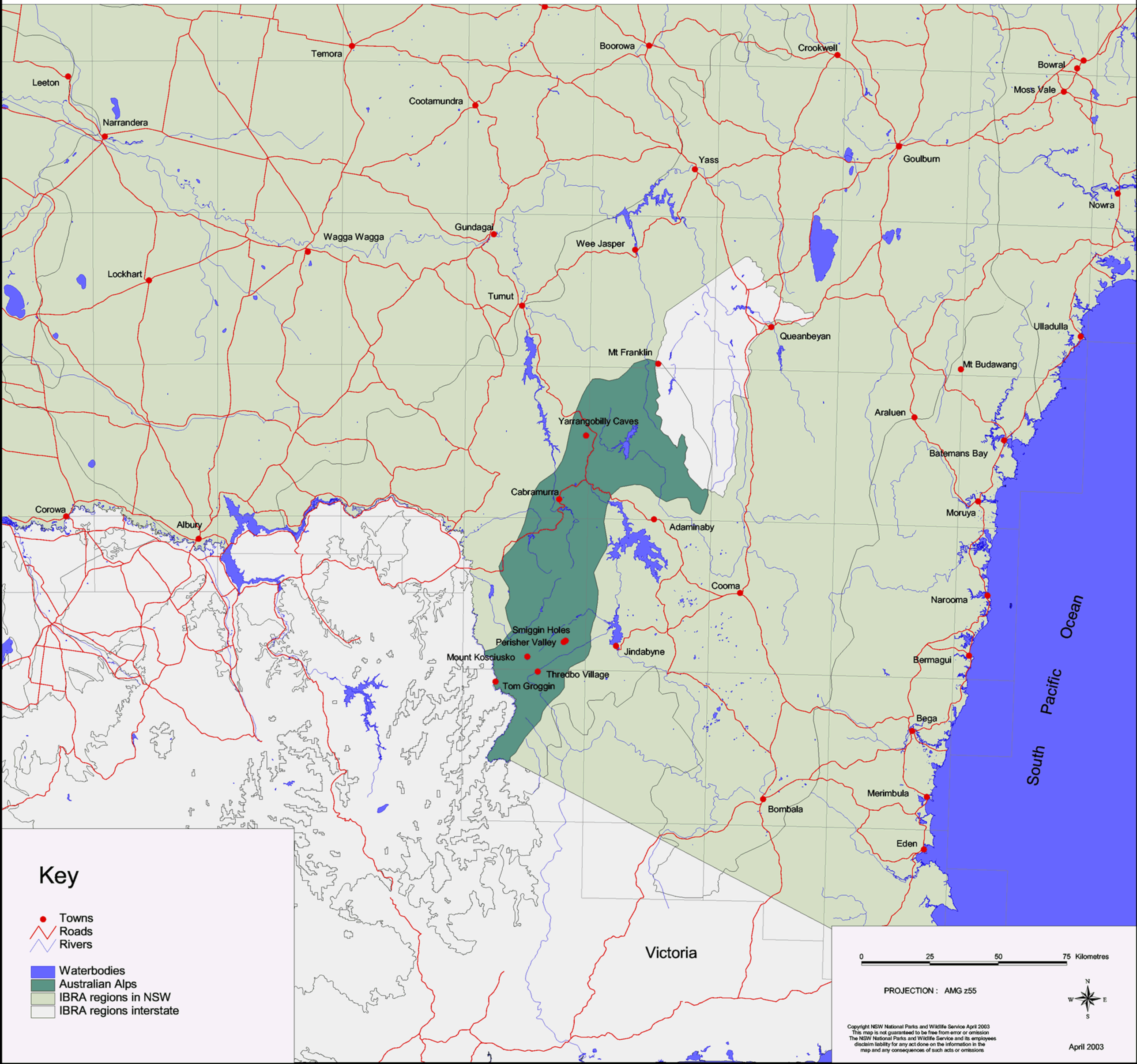
UNESCO – www2.unesco.org/mab/br/brdir/directory/biores.asp

Australian Alps Biogeographic Region (IBRA) - Location



Key

- Towns
- Roads
- Rivers
- Waterbodies
- Australian Alps
- IBRA regions in NSW
- IBRA regions interstate

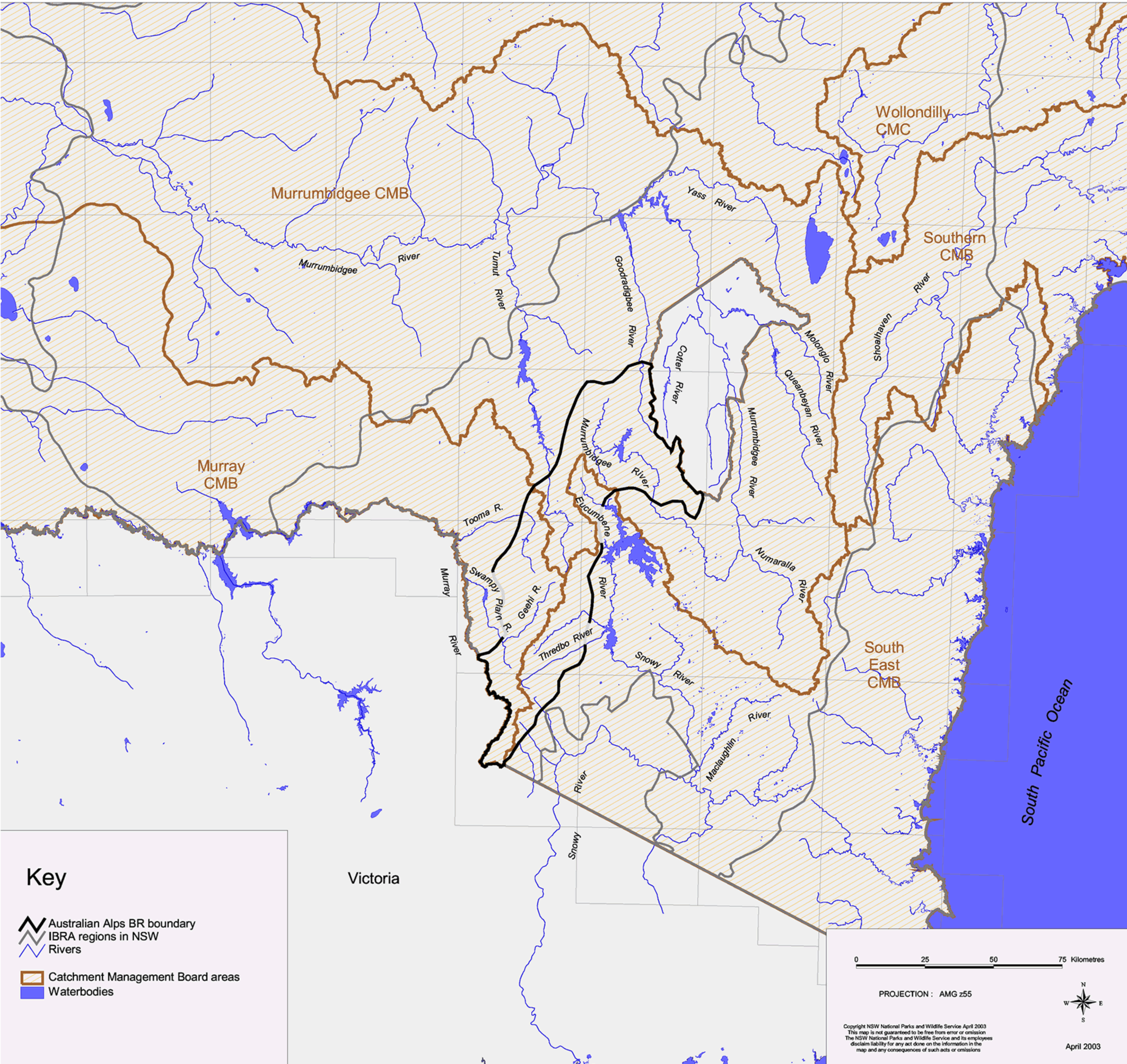
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

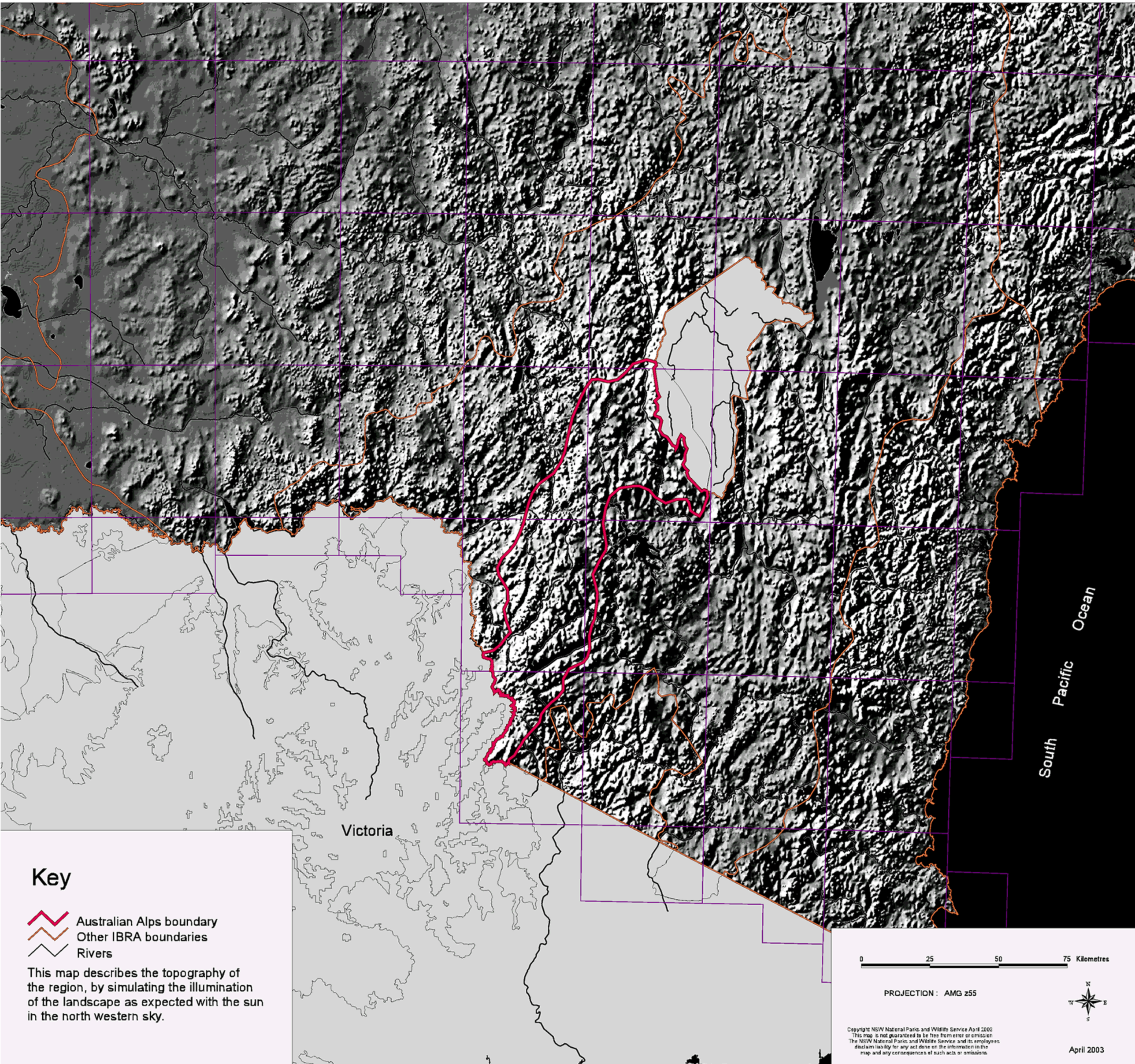
April 2003

Australian Alps Biogeographic Region (IBRA) - Rivers



April 2003

Australian Alps Biogeographic Region (IBRA) - Topography



Key

Australian Alps boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

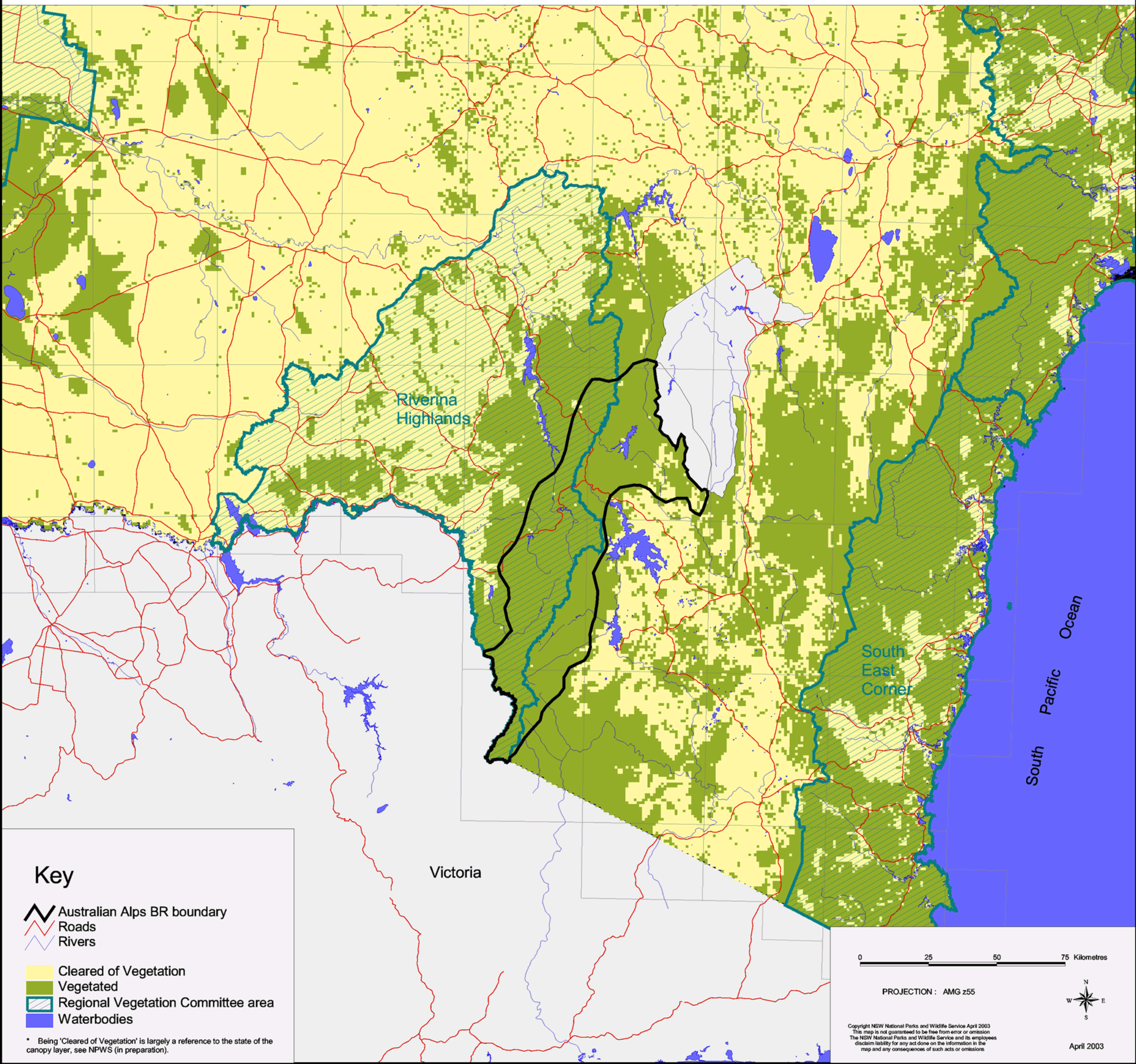
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Australian Alps Biogeographic Region (IBRA) - Vegetation



Key

- Australian Alps BR boundary
- Roads
- Rivers
- Cleared of Vegetation
- Vegetated
- Regional Vegetation Committee area
- Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

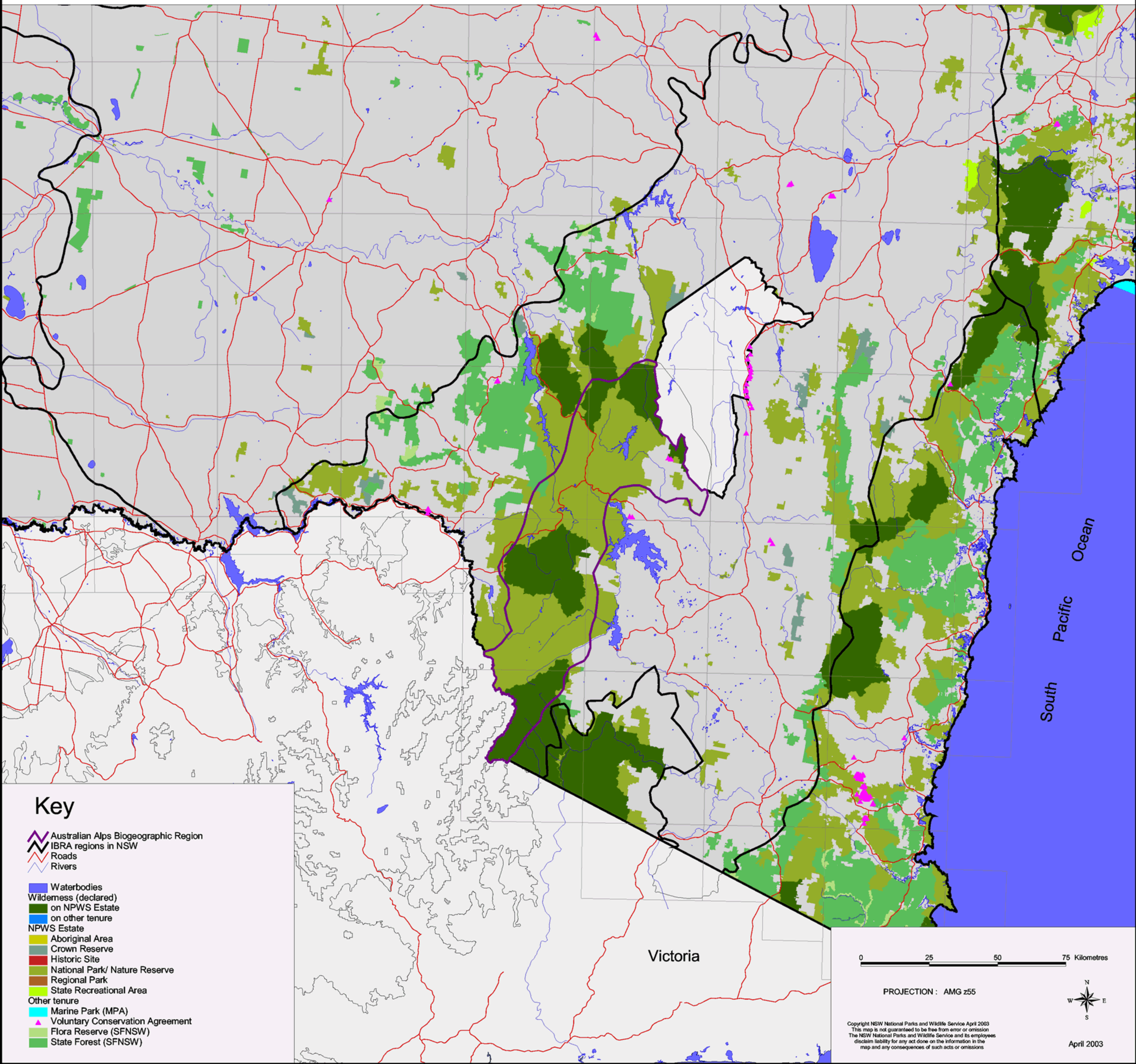
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Australian Alps Biogeographic Region (IBRA) - Tenure/Reserves



Key

- Australian Alps Biogeographic Region
- IBRA regions in NSW
- Roads
- Rivers

- Waterbodies

Wilderness (declared)
- on NPWS Estate
- on other tenure

NPWS Estate
- Aboriginal Area
- Crown Reserve
- Historic Site
- National Park/ Nature Reserve
- Regional Park
- State Recreational Area

Other tenure
- Marine Park (MPA)
- Voluntary Conservation Agreement
- Flora Reserve (SFNSW)
- State Forest (SFNSW)

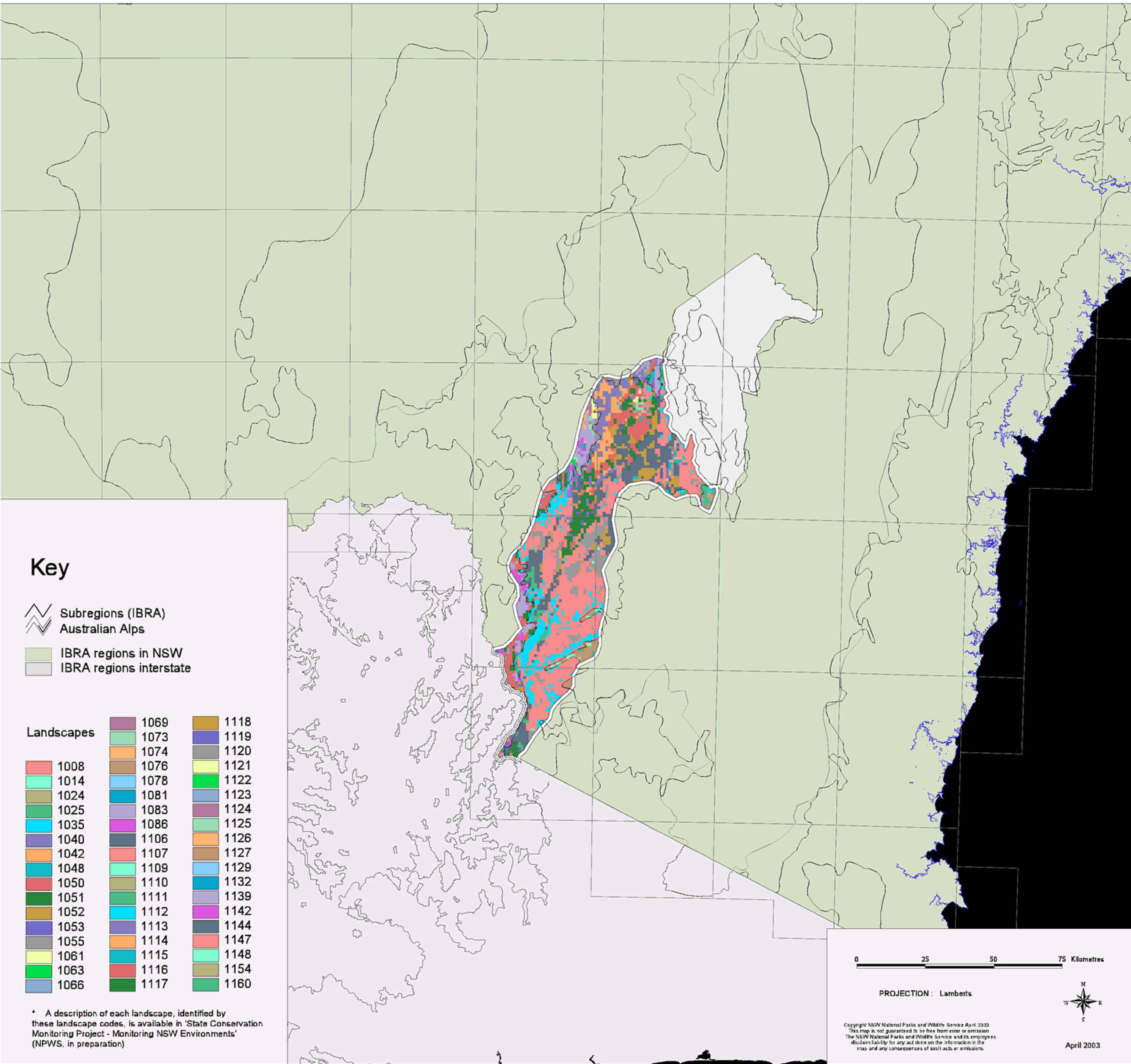
0 25 50 75 Kilometres

PROJECTION : AMG z55

N W E S

April 2003

Australian Alps Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)



CHAPTER 18

The South East Corner Bioregion

1. Location

As the name suggests, this bioregion is in the southeast corner of NSW with a total area of 2,707,639 ha that extends into Victoria. The NSW portion of the bioregion is in two parts; the main body of the bioregion is bordered by Sydney Basin Bioregion to the north and the South Eastern Highlands Bioregion to the west, while a small outlying fragment lies between the Australian Alps and South Eastern Highlands bioregions. Together these areas occupy 48.09% of the bioregion at an area of 1,302,141 ha or 1.63% of NSW.

The bioregion includes the towns of Batemans Bay, Moruya, Narooma, Bermagui, Bega, Merimbula and Eden, most of the bioregion's population living in the towns along the coast.

The Clyde, Deua, Moruya, Buckenbowra, Brogo, Wadbilliga, Towamba, Genoa and Tuross Rivers traverse the bioregion with the main catchments being the Clyde, Deua, Tuross, Bega, Towamba and Genoa catchments.

2. Climate

The part of this bioregion that occurs in NSW is dominated by a temperate climate, characterised by warm summers and no dry season. A small patch of the bioregion in the southwest occurs in a montane climate zone. This area is in the higher country, adjacent to the Australian Alps Bioregion and is characterised by mild summers.

3. Topography

The South East Corner Bioregion is shared between NSW and Victoria. It covers the eastern fall from the Great Dividing Range across the Great Escarpment to the coast. It also includes the upper catchment of the Deddick River and Lower Snowy River gorge. Most of the bioregion is underlain by folded and metamorphosed Ordovician to Devonian sedimentary rocks that have been intruded by several granite bodies. The topography runs from plateau above the escarpment across steep hills toward the coast with short, active streams. Altitude and rainfall affects the vegetation patterns across the bioregion.

Mean Annual Temperature	Minimum Average Monthly Temperature	Maximum Average Monthly Temperature	Mean Annual Rainfall	Minimum Average Monthly Rainfall	Maximum Average Monthly Rainfall
7 – 16°C	-3.5 – 8.4°C	19.2 – 28.8°C	507 – 1523mm	29 – 102mm	58 – 155mm

4. Geology and geomorphology

Basement rocks are folded Ordovician slates, cherts, and quartzite of the Lachlan Fold Belt. Less deformed Devonian sandstones and mudstones overlie the Ordovician rocks and the whole sequence has been intruded by several major granite bodies (about 380 million years old) that now form the bedrock over half of the bioregion. Small areas of Tertiary basalt and local deposits of quartz gravel and sand occur along the coast. Quaternary sediments are relatively unimportant except for the beaches and dunes of small coastal barrier systems.

Different rock types have a strong influence on topography. The metamorphosed sediments are oriented north-south and this controls the overall direction of the coastal ranges. Granites in the Bega Valley weather faster than the surrounding metamorphosed sediments and are eroded into local topographic basins. Other granites with a higher proportion of quartz form steep country with areas of outcrop and rounded tors.

The most prominent feature of the region is the Great Escarpment, a line of steep hills and gorges on the coastal side of the Great Divide that is formed by headward erosion of streams into the continental flexure created at the time of rifting of the Tasman Sea. Most streams have their headwaters at the escarpment but some begin on the plateau above it and flow parallel to the coast for some distance before crossing the escarpment in a gorge with waterfalls. More detailed patterns of stream direction relate to smaller joints and faults in the bedrock and both dendritic and rectangular drainage patterns are present.

Soils vary with bedrock type and slope position and texture contrast profiles dominate. Metamorphic rocks weather to clay and granites weather to a mixture of sand and clay. Metamorphic rocks generally form steeper slopes and thus the soils on them are thin and stony and form a texture contrast profile with thin topsoil of fine sandy loam. The clay subsoil resists the penetration of water and most profiles, especially in lower slope positions, have a strongly bleached zone in the topsoil caused by lateral throughflow. Soils on granites are generally coarser, deeper and better drained and deliver more sandy sediment to the valley floors and the coastline.

The coastline is a mixture of rocky cliffs and small sand barriers built across the mouths of most streams. Unlike the north coast only one phase of barrier development is apparent and soils formed in the dunes are podsol profiles but these only have minimal profile development. Sediments in the estuaries are mainly sand.

5. Geodiversity

Important features include the following:

- cliffs south of Durras have exposed glacio-marine sediments and an unconformity;
- cliffs at Twofold Bay have an excellent example of a faulted fold;
- good examples of pillow lavas can be seen on Narooma Headland;
- Silurian limestone in the upper Deua Valley contains important fossils and has a karst topography;
- the Mt Dromedary monzonite is petrologically unusual;
- Montague Island is composed of monzonite with a cover of dune sand that supports an unusual vegetation community dominated by lomandra (*Lomandra longifolia*) that is apparently affected by high inputs of guano from sea birds; and
- some landscape features such as Mumbulla Mountain have cultural significance to Aboriginal people and still retain story associations.

Photo: M. Van Ewijk

6. Soils

Typical soils found across the South East Corner Bioregion are texture contrast profiles with their properties differing with rock type. Well-drained coarse granite soils are found in the lower Snowy River valley.

7. Biodiversity

7.1 Plant communities

The diversity in topography, rainfall and temperature across the bioregion is reflected in the diversity of vegetation communities across the bioregion.

The coastal headlands support heaths dominated by hakea (*Hakea sericea*), melaleuca (*Melaleuca armillaris*), coast rosemary (*Westringia fruticosa*) and dwarfed red bloodwood (*Corymbia gummifera*). These heath communities occupy shallow soils subject to high salt spray input and frequent fire.

Moving inland, vegetation changes markedly with altitude. Red bloodwood and spotted gum (*Eucalyptus maculata*) forests dominate to an altitude of about 100-200m. Above 200m, yellow stringybark (*E. muellerana*), grey ironbark (*E. paniculata*) and woollybutt (*E. longifolia*) associations are found, with brown barrel (*E. fastigata*), blue-leaved stringybark (*E. agglomerata*), messmate (*E. obliqua*) and monkey gum (*E. cypellocarpa*) associations occurring to about 900m. Narrow-leaved peppermint (*E. radiata*) and snow gum (*E. pauciflora*) are common at the highest altitudes.

Latitude differences are also evident, with Sydney peppermint (*E. piperita*), large-fruited red mahogany (*E. pellita*), Sydney blue gum (*E. saligna*) and spotted gum being found in the northern part of the region. Blue box (*E. bauerana*), bangalay (*E. botryoides*), coastal grey box (*E. bosistoana*) and woollybutt are found further to the south. Granite areas commonly support forest red gum (*E. tereticornis*) and blue gum (*E. globulus*), while black ash (*E. sieberi*) can be found in almost all forest environments.

In the lower Snowy River valley the steep slopes, well-drained coarse granite soils and low rainfall support very different vegetation. Vegetation communities here are dominated by white box (*E. albens*), black cypress pine (*Callitris endlicheri*), and scattered kurrajong (*Brachychiton populneum*). Towards the top of the steeper slopes with northerly aspects, soils derived from volcanic and sedimentary rocks support very rare acacia dry scrub communities dominated by *Acacia silvestris* and *Eriostemon trachyphyllus*. These scrubs are dependent on periodic intense fire for their long-term survival.

Small patches of temperate rainforest with sassafras (*Doryphora sassafras*) and lilly pilly (*Acmena smithii*) occur in gully heads and as a gallery forest along major streams in sheltered locations. River oak (*Casuarina cunninghamiana*) is also present along most steams.

The coastal dune pattern is much the same as elsewhere in NSW with an inland forest of various banksia, bangalay (*E. botryoides*) and blackbutt (*E. pilularis*). Estuaries support small areas of stunted mangrove (*Avicennia marina*) and salt marsh, with a fringe of swamp oak (*Casuarina glauca*).

7.2 Significant flora

Forty-four species from the NSW part of the South East Corner Bioregion are listed in the schedules of the TSC Act (NSW NPWS 2001). Of these, 17 are listed as endangered, 26 are listed as vulnerable and one species, *Prostanthera marifolia*, is considered extinct in the bioregion.

In the outlying portion of the South East Corner Bioregion tall woodland dominated by *E. albens* and *Callitris spp.* is found along dry and exposed aspects of the Snowy River. It is the only occurrence of this association east of the Snowy Mountains and hence a significant one. It is protected in Kosciuszko National Park (NSW NPWS 1988). Another significant association known as the "black scrubs", consisting of a coastal remnant rainforest species, *Acacia sylvestris*, an inland wattle *A. doratoxylon* and a shrub *Eriostemon trachyphyllus*, can also be found in the outlying part of the bioregion (NSW NPWS 1988).

7.3 Significant fauna

Eighty-eight fauna species from the NSW part of the South East Corner Bioregion are listed in the schedules of the TSC Act (NPWS 2001). Of these, 19 are listed as endangered and 69 are listed as vulnerable. Of particular note is the endangered long-footed potoroo (*Potorous longipes*), the only occurrence of which in NSW is in this bioregion. It has been recorded in the South East Forests National Park and nearby state forests (NSW NPWS 1999).

Compared to other bioregions the South East Corner is reasonably intact, with just under 20% of its native canopy having been cleared, but the bioregion is considered to be in the intensive use zone and many forests in the bioregion have been logged intensively (Australian Terrestrial Biodiversity Assessment 2002).

The bioregion supports several threatened bird species, including the vulnerable mainland subspecies of ground parrot (*Pezoporus wallicus*), the southern subspecies of eastern bristlebird (*Dasyornis brachypterus*) in coastal heaths and the eastern subspecies of hooded plover (*Thinornis rubricollis*) on beaches.

The ranges of birds in the bioregion tend to be fairly restricted and, contrary to national trends, a decline in species of forest birds is evident, particularly cockatoos, owls and treecreepers, as well as many smaller bush birds (Australian Terrestrial Biodiversity Assessment 2002). Declines in woodland, ground-feeding insectivores and some grassland birds are also evident. On a more encouraging note, species such as the white-headed pigeon (*Columba leucomela*) and spotted turtle-dove (*Streptopelia chinensis*) seem to have increased in number in the bioregion (Australian Terrestrial Biodiversity Assessment 2002).

7.4 Significant wetlands

There were no bioregionally significant wetlands recorded in the NSW part of the South East Corner Bioregion (Australian Terrestrial Biodiversity Audit 2002). A number of wetlands in the bioregion are regarded as nationally important and listed in the Directory of Important Wetlands in Australia (ANCA 1996).

These wetlands are exposed to a variety of threats including runoff from surrounding urban areas, impacts from feral animals and exotic weeds, grazing pressure, pollution from recreational boating and storm water runoff. Other impacts include increasing fragmentation due to development, changed hydrology from barrage construction, soil erosion from tracks and roads, increasing development and population, construction of marine structures e.g. groynes, professional fishing and recreational four-wheel driving.

8. Regional history

8.1 Aboriginal occupation

The Aboriginal people of the South East Corner Bioregion referred to themselves as "Katungal" which distinguished them from those who occupied the inland and mountain areas (HO and DUAP 1996). The river basins of the Towamba and Bega Rivers were occupied by the Taua and Djiringanj groups respectively, while the Walbanga people considered their territory to be the valleys north of the Tuross and Moruya Rivers (HO and DUAP 1996). In essence, these four main waterways were home to the three Aboriginal groups of the bioregion and because all three groups were confined to the coast by the mountains in the west they led a largely coastal lifestyle (HO and DUAP 1996). Since the coast offered plentiful food supplies and the groups occupied fairly small homelands, the Aboriginal communities of the South East Corner Bioregion were relatively less mobile compared to those groups of the inland areas of the south (HO and DUAP 1996).

In the early 1800s, as explorers and, subsequently, early settlers began to encroach on the homelands of the Aboriginal people, violence and altercations occurred. The peaceful coastal life of the Katungal people became more and more disrupted.

8.2 European occupation

The 1820s saw the advent of the agricultural era with the arrival of cattlemen and their stock, and the 1830s and 40s marked the start of increasingly permanent European settlement in the bioregion (HO and DUAP 1996). During this time European settlers used the best land for agriculture and the best fishing locations for themselves, preventing the local Aboriginal people from using these resources in their traditional ways (HO and DUAP 1996). Hence in the 1840s many Aboriginal people sought work with the new settlers, men undertaking sheep washing or agricultural labour while women worked as domestic servants.

In these early years of European settlement, the pastoral industry developed slowly due to infrequent communications with the colony in Sydney, but soon after a significant whaling industry developed in Twofold Bay, near the present site of Eden (HO and DUAP 1996). Whaling, which occurred from the 1830s to the1920s, involved and depended on the local Aboriginal community, many of whom played an essential role in the industry as a significant component of the labour force. Despite this integration into the workforce and although they built good working relationships with the Europeans while managing some "continuity of traditional culture and social structure" (HO and DUAP 1996), the Aboriginal people were unable to wholly preserve their traditional way of life.

Mining also played a part in the history of the South East Corner Bioregion, with many prospectors finding gold, silver and, fleetingly, arsenic in the wooded hills of the area between Batemans Bay and Eden (HO and DUAP 1996). Gold was first recorded in 1852 and has been mined in the area since then, although there are currently no active gold mines in the area (NSW Department Mineral Resources website – http://www.minerals.nsw.gov.au/). The mining industry became the basis for numerous towns, which prospered with populations of hundreds until the end of the frenetic periods of mining, then gradually faded as the prospectors departed.

The forests of the bioregion were logged to resource the construction of houses, wharves and the railway system, although the most controversial large-scale logging of the bioregion has occurred in more recent years (HO and DUAP 1996).

While beef cattle and sheep farming was the original intent of many landholders in the region, dairy farming soon surpassed these ventures as the principal agricultural industry of the area. By the twentieth century, the Bega Valley was the dominant milk and cheese producer of southern NSW and Canberra, although the region has always produced more butter than cheese (HO and DUAP 1996). The dairying industry in the area was not achieved without vast clearing of the natural woodland that covered the region previously.

Other important industries include pig farming, maize and sorghum production and fishing.

9. Bioregional-scale conservation

The South East Corner Bioregion is managed in conservation tenures that together occupy about 561,434.41 ha or 43.31% of the bioregion.

There are 18 national parks, 12 nature reserves and 2 Crown reserves wholly or partly in the bioregion, and together these occupy 547,079.38 ha or 42.20% of the bioregion. Nine wilderness areas (Brogo, Bedewing, Burra Oulla, Byadbo, Genoa, Nadgee, Pilot, Woila Deua, and Yowrie) occupy much of the reserved area of the region, together occupying about 224,602 ha or 17.25% of the bioregion. Davidson Whaling Station Historic Site occupies 15.98 ha, a small percentage of the bioregion, and there are no Aboriginal areas, no karst areas, no state recreation areas and no regional parks in the bioregion.

NPWS-managed Crown reserves under the Crown Lands Act occupy 848.48 ha or 0.07% of the bioregion.

Some landholders in the bioregion have entered into private land conservation agreements under the provisions of the NPW Act 1974 or the NVC Act 1997. In recent years, landholders have entered into 26 voluntary conservation agreements, which together occupy about 711 ha or 0.05% of the bioregion. Landholders on 9 properties also hold wildlife refuges which occupy 1205.43 ha or 0.09% of the bioregion (updated mapping, being undertaken at the time of writing, is likely to increase this figure). In addition there are 4 property agreements in the bioregion under the NVC Act 1997 which occupy about 143.42 ha or 0.01% of the bioregion. Together these areas of private land conservation total 2059.94 ha or 0.16% of the South East Corner Bioregion.

Seventeen flora reserves managed under the provisions of the Forestry Act 1916 occupy 8,576.25 or 0.66% of the bioregion and these contribute towards biodiversity conservation. In addition the bioregion includes State forests which are managed primarily for forestry activities under the Forestry Act 1916 and occupy 323,757.86 ha or about one quarter (24.86%) of the bioregion.

Land given protection by State Environmental Planning Policies in the bioregion includes 5,844.66 ha (0.45%) of SEPP 14 coastal wetlands, 3.01 ha (0.0002%) of SEPP 26 Littoral Rainforests and 16,505.23 ha or 1.27% of SEPP 58 (Protecting Sydney's Water Supply).

Photo: I. Brown

10. Subregions of the South East Corner Bioregion

(Morgan 2001)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Bateman	Tightly folded fine grained Ordovician metamorphic rocks with several intrusions of granite. Western margin is a tight synclinal fold in Devonian sandstone and siltstone. Small areas of Tertiary basalt and quartz sands behind the coastal headlands. Quaternary alluvium on main valley floors and in the estuaries.	Steep hills below the Great escarpment oriented north-south and controlled by rock structure. Lines of hills become lower toward the coast with a slight up turn along the coastal margin. Coastal barrier systems are small and estuarine fills limited.	Mostly texture contrast soils. Red clay subsoils with thin topsoil on metamorphic rocks, deeper coarser grained profiles on granite. Red brown structured loams on basalt and deep siliceous sands with some podsol development on Tertiary sands and coastal dunes.	Hakea, melaleuca, coast rosemary and dwarfed red bloodwood heath on headlands. Red bloodwood and spotted gum forests to 300 m. Yellow stringybark, grey ironbark and woollybutt to 550 m. Brown barrel, black ash, Sydney peppermint, large-fruited red mahogany, Sydney blue gum and monkey gum to 900 m, then snow gum.
East Gippsland Uplands	Extensive areas of granite amongst Ordovician and Silurian metamorphosed sedimentary and volcanic rocks; slates, chert, quartzites. Gently folded red and purple Devonian sandstones and shales, limited areas of Tertiary basalt and sand deposits. Quaternary coastal sediments and small areas of alluvium.	Very abrupt margin on the Great Escarpment. Deep gorges with rapids and waterfalls in the main streams including the lower Snowy River. Extensive subdued basin with rolling hills on the Bega granite with steep hillslopes at the contact aureole. Streams carry large volumes of sand to valley floors and estuaries. Small beach, dune, lagoon barrier systems.	Coarse texture contrast soils on granite, thinner profiles on metamorphics with red and yellow clay subsoils. Deep coarse sands in granite derived alluvium often deposited in swampy valley flats. Deep fine sands in dunes. Peaty sands in lagoons and swamps.	Red bloodwood and spotted gum forests to 300 m. Spotted gum less common in the south. Yellow stringybark, grey ironbark, black ash, yertchuk and woollybutt to 550 m. Brown barrel, black ash, large-fruited red mahogany, and monkey gum to 900 m, then snow gum.
East Gippsland Lowlands	Granites in the head of the Genoa River. Small areas of Devonian sandstone overlain by Tertiary sands and Quaternary coastal dunes near Cape Howe.	Low rounded coastal hills on granite, higher and steeper on Devonian sandstones. Beach, dune and lagoon barrier development on the main streams with dunes some distance inland at Cape Howe.	Coarse texture contrast soils on granite, subject to high rates of erosion even under forest cover. Deep sands in dunes. Peaty sands in lagoons and swamps.	Coastal sequence on dunes with thickets of coast tea-tree and sedge communities around swamps. Stunted black ash and red bloodwood clumps close to the coast becoming taller inland with bangalay, rough-barked apple, river peppermint, coast grey box, black she-oak and blue gum.

11. References

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NSW NPWS 1988. *Kosciuszko National Park Plan of Management*. Second Edition. NSW National Parks and Wildlife Service, Hurstville.

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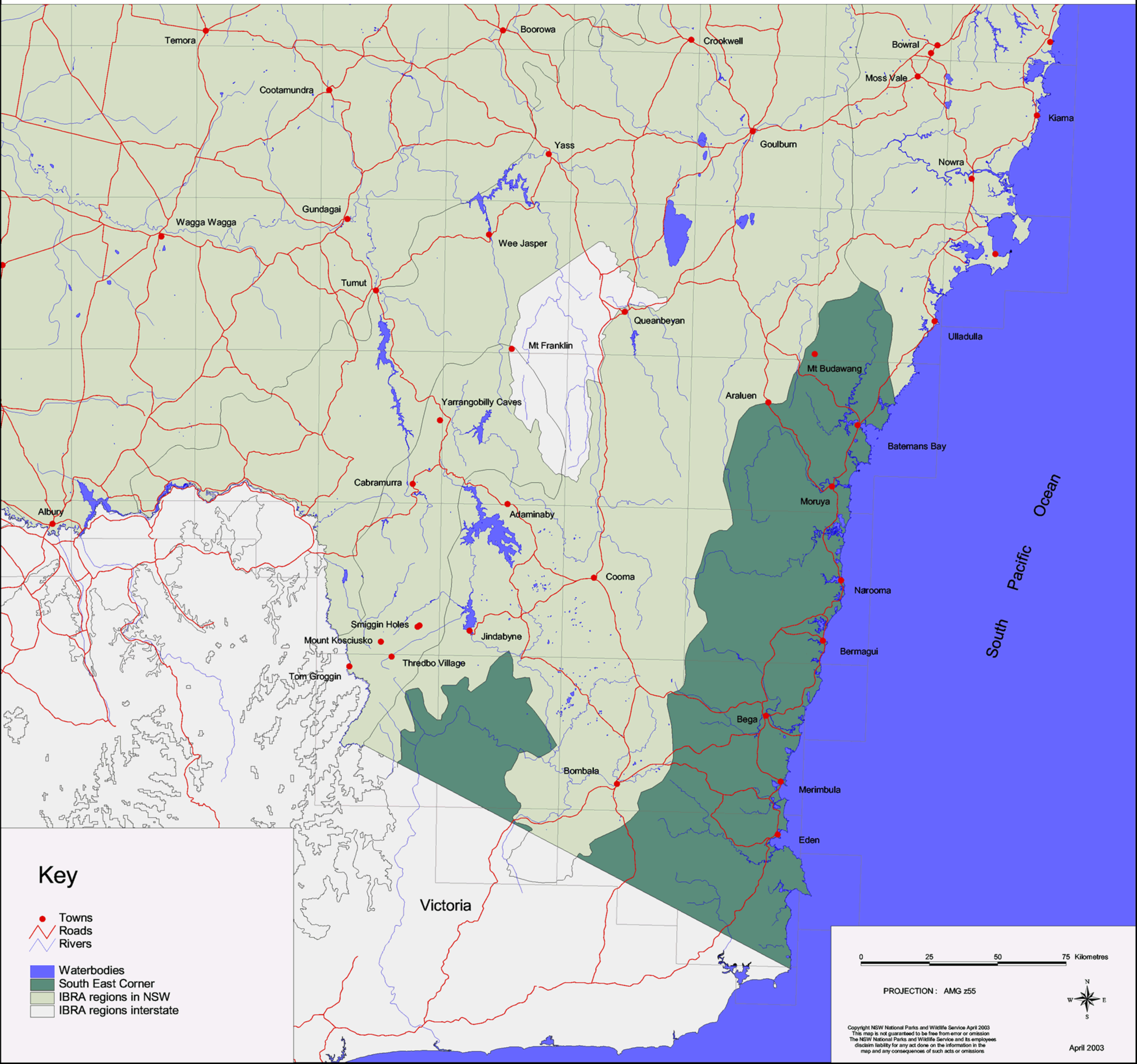
Website

NSW Department Mineral Resources – http://www.minerals.nsw.gov.au/

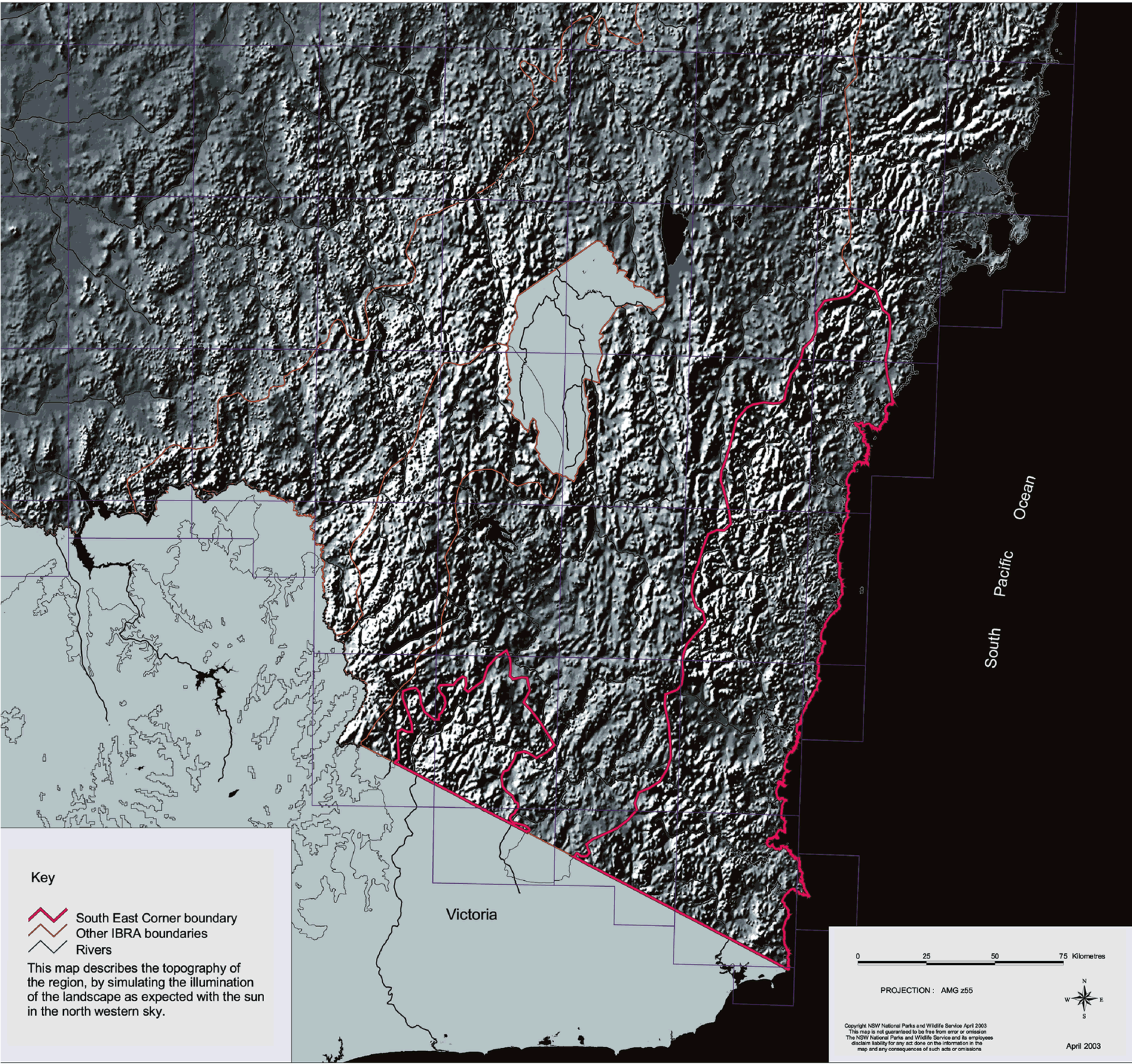
South East Corner Biogeographic Region (IBRA) - Location



April 2003

South East Corner Biogeographic Region (IBRA) - Rivers

South East Corner Biogeographic Region (IBRA) - Topography



Key

South East Corner boundary
Other IBRA boundaries
Rivers

This map describes the topography of the region, by simulating the illumination of the landscape as expected with the sun in the north western sky.

0 25 50 75 Kilometres

PROJECTION : AMG z55

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W E
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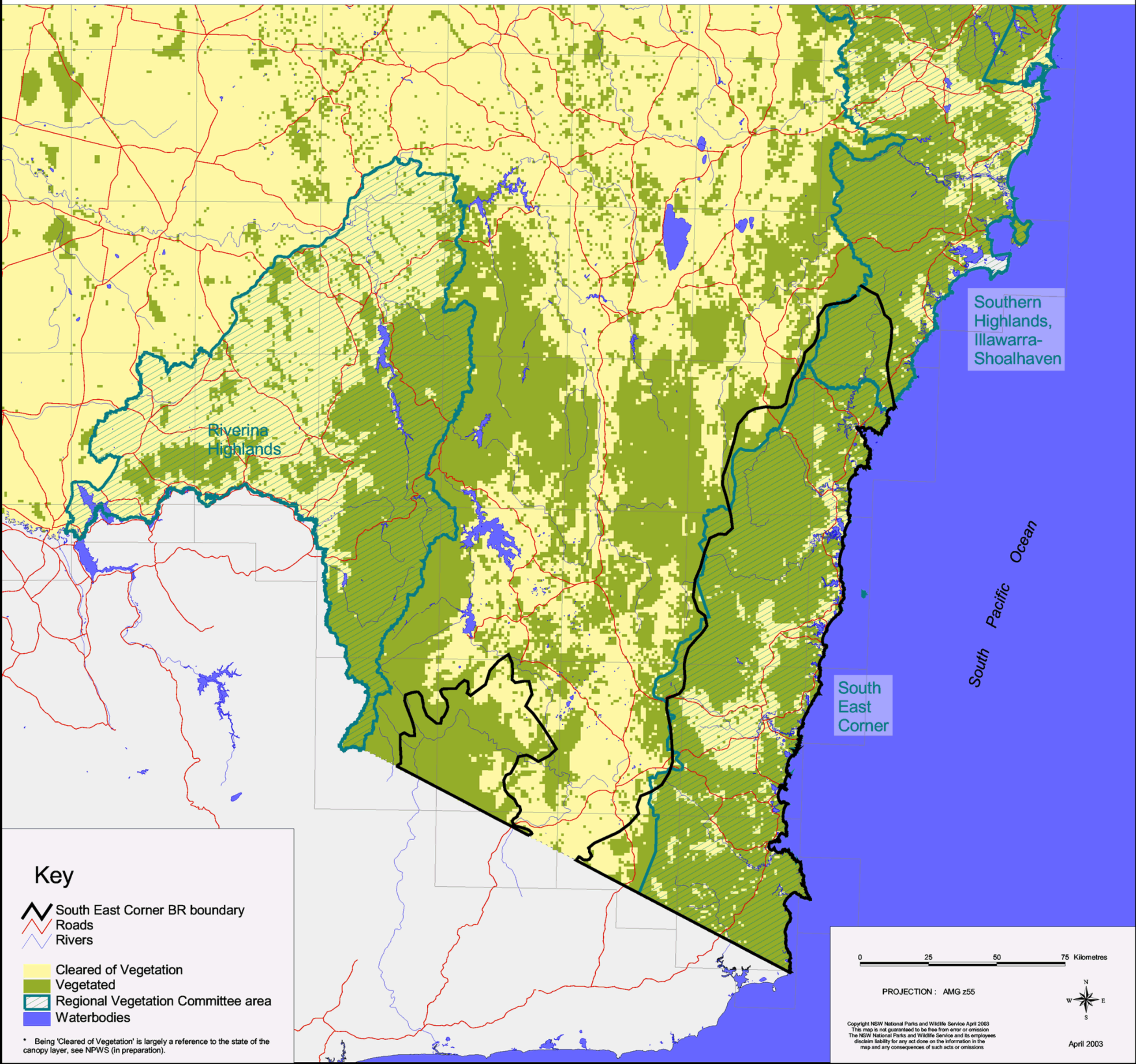
April 2003

South East Corner Biogeographic Region (IBRA) - Vegetation



Key

South East Corner BR boundary
Roads
Rivers

Cleared of Vegetation
Vegetated
Regional Vegetation Committee area
Waterbodies

* Being 'Cleared of Vegetation' is largely a reference to the state of the canopy layer, see NPWS (in preparation).

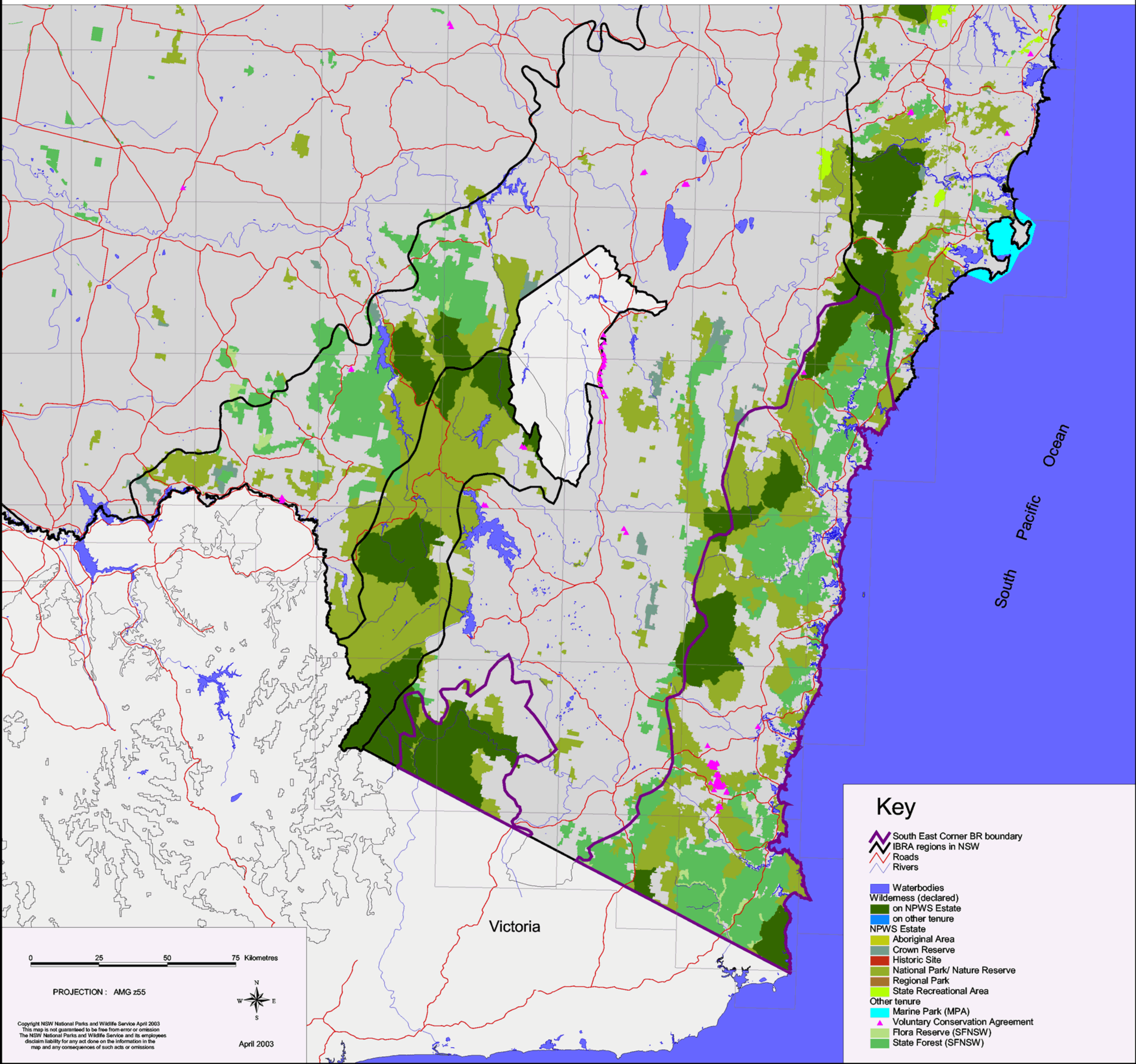
0 25 50 75 Kilometres

PROJECTION : AMG z55

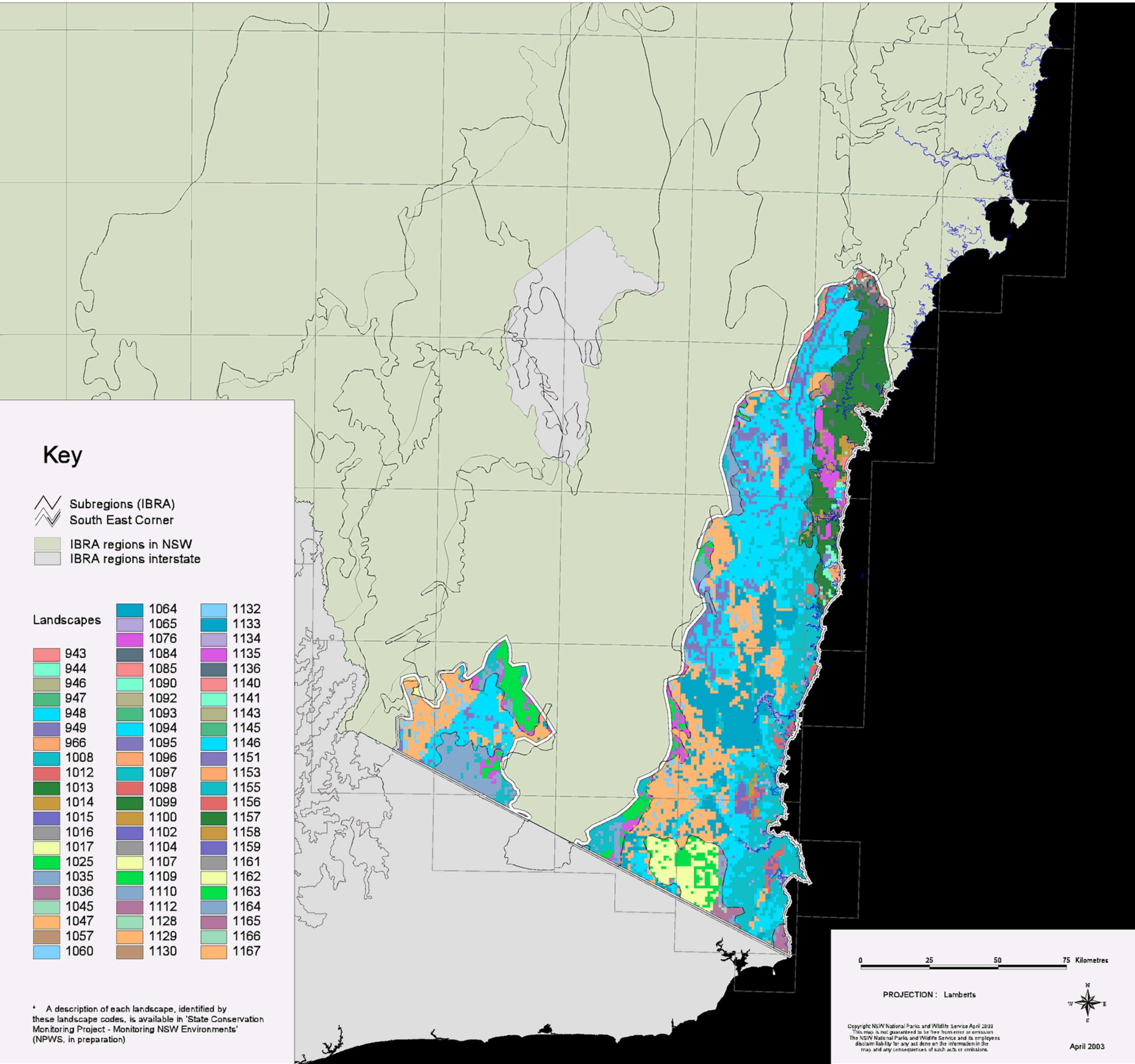
N W E S

April 2003

South East Corner Biogeographic Region (IBRA) - Tenure/Reserves



South East Corner Biogeographic Region (IBRA) - Subregions and Landscapes (NPWS, in preparation)

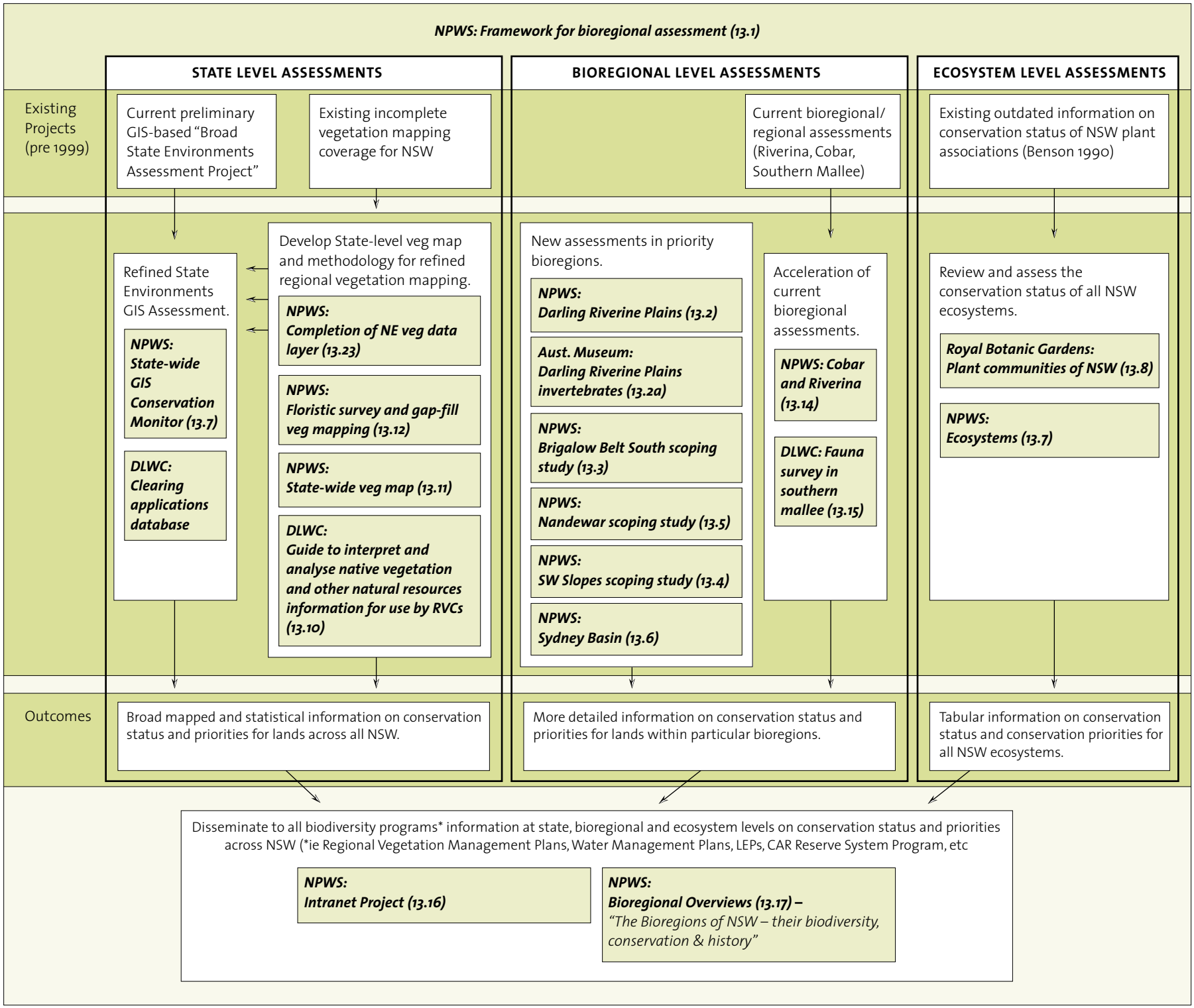


* A description of each landscape, identified by these landscape codes, is available in 'State Conservation Monitoring Project - Monitoring NSW Environments' (NPWS, in preparation)

Appendices

APPENDIX 1

Diagram of Integrated Biodiversity Conservation Assessment (IBCA) projects funded under the NSW Biodiversity Strategy



APPENDIX 2

The conservation mechanisms surveyed and described in the chapter for each bioregion

High security conservation-oriented mechanisms (Smart 2002)

Name	Legislation	Description	Security
Nature Reserve	*National Parks and Wildlife Act 1974 (NPW Act)*	49(3)-8(2) areas of special scientific interest containing wildlife or natural environments or natural phenomena	Revocation requires Act of Parliament.
National Park	*NPW Act*	8(2)(a) spacious areas containing unique or outstanding scenery or natural phenomena	Revocation requires Act of Parliament.
Karst Conservation Reserve	*NPW Act*	58K(3)-8(2) (c2) areas of scientific, recreational, aesthetic or historical value within karst regions	Revocation requires Act of Parliament.
Historic Site	*NPW Act*	The "sites of buildings, monuments or events of national significance or areas in which relics, or Aboriginal places, of special significance are situated" (s. 8(2)(b)). Historic sites can consist of Crown Land, land owned by government bodies and land especially acquired for the purpose (s. 33(1)).	Revocation requires Act of Parliament.
Flora Reserve	*Forestry Act 1916*	(S. 25A) Flora Reserves are areas of Crown land or parts of State Forests designed to preserve native flora.	Revocation requires Act of Parliament.
Declared Wilderness	*Wilderness Act 1987*	S3 – to provide for the permanent protection and proper management of wilderness. To restore and to protect the unmodified state of the area and its plant and animal communities; to preserve the capacity of the area to evolve in the absence of significant human interference; and to permit opportunities for solitude and appropriate self-reliant recreation.	Revocation requires Act of Parliament.

Mechanism	Governing legislation	Purpose as defined in legislation	Conservation effectiveness. Is nature conservation the primary purpose of the mechanism?	Security of mechanism. How easily can protection offered by the measure be circumvented or varied?	IUCN protected area category if applicable
Special areas or catchment areas on land managed under the *NPW Act*	*NPW Act* and various pieces of legislation controlling catchment and special areas in catchments including: *Water Management Act 2000* and *Sydney Water Act 1994*	There are additional restrictions on activities within these areas. Under the *NPW Act S74* a plan of management for lands reserved or dedicated under the *NPW Act* or which comprise wilderness within the meaning of the *Wilderness Act 1987* are wholly or partly in a catchment area or special area of a water authority, or the waters from any lands so reserved or dedicated that drain into a catchment area, special area or structure of a water authority, must be referred to the relevant water authority for its information, and also referred to the Director-General (DG) of the Department of Water Resources if the relevant water authority is the Hunter Water Corporation. S185 *NPW Act*. (4) prevents the issuing of a lease, license, or right of way under the *NPW Act* in a catchment area or special area within the meaning of the *Water Board (Corporatisation) Act 1994*, except with the concurrence of Sydney Water Corporation, or (b) the *Hunter Water Board (Corporatisation) Act 1991*, except with the concurrence of the Hunter Water Corporation and the Director of the Department of Water Resources. Neither Sydney Water Corporation nor the Hunter Water Corporation nor the DG of the Department of Water Resources shall, except with the concurrence in writing of the DG, undertake or arrange for the cutting and marketing of timber of commercial value on lands within a national park, historic site, state recreation area, regional park, nature reserve, state game reserve, karst conservation reserve or Aboriginal area that are also lands within a catchment area or special area.	Yes	Revocation requires an Act of Parliament	I-III where management includes management under the *NPW Act*

Medium security (mechanism is described in legislation and confers specific management, but does not require parliamentary action for removal), nature conservation-oriented, land management strategies available in NSW.

Mechanism	Governing legislation	Purpose as defined in legislation	Conservation effectiveness. Is nature conservation the primary purpose of the mechanism?	Security of mechanism. How easily can protection offered by the measure be circumvented or varied?	Planned management. Does legislation require that the protection measure be managed under a Plan of Management?	IUCN protected area category if applicable
Conservation Agreement	*National Parks and Wildlife Act 1974 (NPW Act)*	69C(1) a-f: Conservation Agreements (CAs) are entered into on private lands in relation to areas that contain: scenery, natural environments, natural phenomena worthy of preservation; special scientific interest; sites of buildings, objects, monuments or events of national significance; relics or Aboriginal places (where they are situated); value for study, preservation, protection and care of flora, fauna and karst regions.	Case by case.	An agreement may be varied by a subsequent agreement between the Minister and the owner of the conservation area	A Plan of Management may be prepared.	Case by case.
Conservation Agreement in Wilderness area (applies to private land)	*Wilderness Act 1987*	A CA can be entered into in relation to land identified as Wilderness under the *Wilderness Act 1987*, and also to freehold or Crown Lease (not managed by statutory authority) land. A CA under such circumstances cannot contain terms inconsistent with the management principles for Wilderness areas as identified in the *Wilderness Act*.	Yes	Can be varied or revoked in accordance with the revocation statutes of S 8(4) of the *Wilderness Act* or S 69D of the *NPW Act*.	A Plan of Management may be prepared and needs to be consistent with the requirements of wilderness protection defined in the *Wilderness Act*.	I
Wilderness Protection Agreement (applies to land of the Crown)	*Wilderness Act 1987*	Purpose is for conservation and restriction of use and access (s.S.12 (1) a-i. Relates to land that is: 1) owned by the Crown or land owned or controlled by a statutory authority; and that is 2) identified as Wilderness (i.e. not yet declared as Wilderness) (s. 10(1)).	Yes	If the Wilderness declaration is revoked, the WPA is revoked; it can be varied by the parties to the agreement.	Not a requirement but can be done. They are not necessary if the NPWS has already caused a plan of management to be prepared for the wilderness area. They cannot be inconsistent with the management of wilderness (S.17).	Ib
Wildlife Refuge	*NPW Act 1974*	68(2): Wildlife Refuges (WRs) are dedicated for the purposes of: preserving, conserving, propagating and studying wildlife; conserving and studying natural environments; and creating simulated natural environments.	Yes	S.68 3 (b) May be revoked at any time by request in writing.	A management plan may be prepared under S (78).	May or may not meet criteria. Could meet categories IV-VI

Mechanism	Governing legislation	Purpose as defined in legislation	Conservation effectiveness. Is nature conservation the primary purpose of the mechanism?	Security of mechanism. How easily can protection offered by the measure be circumvented or varied?	Planned management. Does legislation require that the protection measure be managed under a Plan of Management?	IUCN protected area category if applicable
State Environmental Planning Policy (SEPP), SEPP 14 Coastal Wetlands	*Environmental Planning and Assessment Act 1979 (EPA Act)*	(s. 37-39) SEPPs address issues of state-wide significance, when state-wide application of policy is necessary. A SEPP is made for any matter which, in the opinion of the DG or Minister for Planning, is of significance for environmental planning for the State. A SEPP provides that development consent from the local council be necessary for specified activities. It also provides for exceptions. Preservation and protection of coastal wetlands in the environmental and economic interests of the state.	Yes	Exceptions to activities allowed on SEPP 14 wetlands require consent from the council and DG Planning and is required to account for representations of DG NPWS.	Not required	
State Environmental Planning Policy (SEPP), SEPP 19 Urban Bushland	*EPA Act 1979*	Preservation of bushland within the Local Government Areas (LGAs) of Sydney Region, Gosford and Port Macquarie, because of: its value to the community as part of the natural heritage; its aesthetic value; its value as a recreational, educational and scientific resource.	Yes	Consent from council is needed for the disturbance of any part of bushland within land zoned or reserved for public open space (with 3 exceptions). Utilities not requiring development consent still require environmental assessment under EPA Act.		
State Environmental Planning Policy (SEPP), SEPP 26 Littoral Rainforest	*EPA Act 1979*	The Policy provides that listed developments shall not be carried out on the littoral rainforest core or the buffer zone, without consent.	Yes	Forbidden developments require consent of the local council and the concurrence of the DG of Planning NSW or, in the case of a development by a Crown authority, the Minister for Planning.		
Property Agreements	*Native Vegetation Conservation Act 1997 (NVC Act)*	A Property Agreement (PA) may: identify land or vegetation to be set aside for conservation or rehabilitation purposes; outline methods, practices and outcomes for vegetation management; provide financial and technical assistance to the landholder with respect to vegetation management; and other matters. (s.41, 42)	Conservation and management of native vegetation.	A PA remains in force for a period specified in the agreement. A PA may be varied by a subsequent agreement between the parties to the agreement. Also, a PA may be terminated at any time with the consent of the parties to the agreement.	A PA is a plan of management. It makes provisions for conservation and management of the specified land.	Case by case. Depends on intention and time period specified.

Medium security to low security (primarily educative), not nature conservation-oriented, land management strategies available in NSW.

Mechanism	Governing legislation	Purpose as defined in legislation	Conservation effectiveness. Is nature conservation the primary purpose of the mechanism?	Security of mechanism. How easily can protection offered by the measure be circumvented or varied?	Planned management. Does legislation require that the protection measure be managed under a Plan of Management?	IUCN protected area category if applicable
Aboriginal Area	*National Parks and Wildlife Act 1974 (NPW Act)*	62(4)-8(2)(d) areas in which relics, or Aboriginal places, of significance are situated	No	Can be revoked by the Governor, published in the Gazette.	Yes	NA
State Recreation Area	*NPW Act 1974*	47B (1)-8(2) (b1) areas containing features of regional recreational significance in a natural setting and which are capable of providing a range of recreational opportunities without detriment to the natural environment or cultural significance of the place.	No	Revocation requires Act of Parliament	Yes	NA
Regional Park	*NPW Act 1974*	8(2) (b2) Areas substantially modified since European occupation and that: (i) are capable of providing open space and recreational opportunities for major regional population centres, and (ii) are unsuitable for reservation or dedication as another category	No	Removed by an Act of Parliament	Yes	NA
Conservation Agreement	*NPW Act 1974*	69C(1) a-f: CAs are entered into on private lands in relation to areas that contain: scenery, natural environments, natural phenomena worthy of preservation; special scientific interest; sites of buildings, objects, monuments or events of national significance; relics or Aboriginal places (where they are situated); value for study, preservation, protection and care of flora, fauna and karst regions.	Case by case, can be directed towards cultural heritage conservation only.	An agreement may be varied by a subsequent agreement between the Minister and the owner of the conservation area	A Plan of Management may be prepared following consultation with the owner 72E.	Case by case.
Ramsar wetland	Ramsar Convention on Wetlands. *Environment Protection and Biodiversity Conservation (EPBC) Act 1999. (Common-wealth legislation)*	Environment Protection and Biodiversity Conservation Regulations No. 181 Schedule 6 Managing wetlands of international importance (Regulation 10.02) 1 General principles 1.01 The primary purpose of management of a declared Ramsar wetland must be, in accordance with the Ramsar Convention: (a) to describe and maintain the ecological character of the wetland; and (b) to formulate and implement planning that promotes: (i) conservation of the wetland; and (ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.	Yes.	A Plan may be varied, revoked or amended by the Minister (managing the *EPBC Act*).	A Plan must be made only by the Minister (managing EPBC Act) if that land is Common-wealth territory (with some caveats for some of the Commonwealth reserves). The Commonwealth must try to prepare and implement a management plan for Ramsar wetlands in cooperation with states where the wetland is in state territory.	

Mechanism	Governing legislation	Purpose as defined in legislation	Conservation effectiveness. Is nature conservation the primary purpose of the mechanism?	Security of mechanism. How easily can protection offered by the measure be circumvented or varied?	Planned management. Does legislation require that the protection measure be managed under a Plan of Management?	IUCN protected area category if applicable
World Heritage listing	World Heritage Convention and in Australia the *World Heritage Conservation Act 1983, Environment Protection and Biodiversity Conservation Act 1999*	Natural and cultural places that are of "outstanding universal value and which meet the strict criteria of the World Heritage Convention may be entered on the list compiled by the World Heritage Committee". *Environment Protection And Biodiversity Conservation Act 1999* – S. 14 (1) sets out that the Minister may declare a specified property to be a declared World Heritage property by notice in the *Gazette* if : (a) the property is a property submitted by the Commonwealth to the World Heritage Committee under Article 11 of the World Heritage Convention as suitable for inclusion in the World - Heritage List; or (b) the Minister is - satisfied that: (i) the property has, or is likely to have, world heritage values; and - (ii) some or all of the world heritage - values of the property are under threat. -	Case by case, can also be for the protection of cultural heritage.	Declaration can be amended or revoked.	A plan of management is not required under the *World Heritage Conservation Act 1983*. Regulations may prescribe ways of giving effect to the Act.	

Low security (land management relies on other mechanisms for security or goodwill), nature conservation oriented land management strategies available in NSW.

Mechanism	Governing legislation	Purpose as defined in legislation	Conservation effectiveness. Is nature conservation the primary purpose of the mechanism?	Security of mechanism. How easily can protection offered by the measure be circumvented or varied?	Planned management. Does legislation require that the protection measure be managed under a Plan of Management?	IUCN protected area category if applicable (does not apply to cultural heritage and may vary on a case by case basis)
Indigenous Protected Area	No statutory basis	A program developed by Environment Australia (EA) to provide the opportunity for agreements to be made between the Commonwealth government and indigenous groups over lands owned or controlled by indigenous people that would fund and assist indigenous communities to manage their lands for conservation of biodiversity	Yes	Not secure	No	
Register of National Estate	*Australian Heritage Commission Act 1975*	A nation-wide heritage list for Australia that encompasses natural, indigenous and historic places. The Register is compiled by the Australian Heritage Commission.	Case by case, can also be cultural heritage.	Listing in the Register of the National Estate does not legally affect management of a place unless it is a property owned by the Commonwealth	No legal protection unless offered by another mechanism or on Commonwealth land.	

APPENDIX 3

Conservation status analysis of each bioregion in NSW based on protection of landscapes within formal conservation management mechanisms.

Landscape 1107 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion AA1 – New South Wales Alps.

Landscape 1120 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion AA1 – New South Wales Alps.

AUSTRALIAN ALPS

Landscape-scale conservation

The Australian Alps Bioregion in NSW consists of 53 landscapes (NPWS in prep). The bioregion is dominated by one extensive landscape (Landscape 1107), with 30.18 % of the NSW area of the bioregion, and 38 landscapes occupying less than 1% of the bioregional area. There are 13 landscapes occupying areas of 1-13% of the bioregional area.

At a bioregional scale, the conservation of the Australian Alps Bioregion in NSW is comprehensive in that a large proportion of the bioregion is included in conservation management, particularly national parks and nature reserves. However some landscapes are not (or are minimally) represented in conservation areas and are highly cleared. This increases the priority for managing these landscapes within some form of conservation-oriented program.

National parks and nature reserves

Two of the 53 landscapes are not represented in national parks or nature reserves and only 5 of the landscapes have less than 20% of their area in reserves. Eighteen landscapes occur wholly (100%) within Kosciuszko National Park and nearby nature reserves, and a further 17 have greater than 90% of their area within these reserves.

Voluntary conservation agreements and wildlife refuges

The voluntary conservation agreements and wildlife refuges occupy landscapes that also have high reservation status (area included in national park or nature reserve, which with wilderness offers the most secure form of conservation management). Only a small proportion of the landscapes are cleared.

Property agreements

Similarly to voluntary conservation agreement and wildlife refuges, the conservation zone of the property agreement occurs on two landscapes (1107, already described, and 1120, an area of low ruggedness) which have high reservation status and only a small proportion cleared.

Conservation and clearing

While only a relatively small proportion (about 14,200 ha or 3.32%) of the NSW part of the Australian Alps Bioregion has been cleared of its native woody canopy, this clearing has been concentrated in only a few landscapes, some of which are not well conserved in reserves and are not represented in other forms of conservation-oriented management. Eighteen of the landscapes have undergone some degree of clearing of their native canopy. Of these, 6 have lost 30% of their area to clearing, 2 landscapes (1014 and 1024, both having low ruggedness) have been 100% cleared, and a further 2 have lost more than 50% of their NSW bioregional area to clearing.

Of this group of highly cleared landscapes, the 2 which are totally cleared are not represented in any form of management surveyed, and 5 have a representation of less than 6% in any form of conservation management. Those landscapes having low representation in the more secure forms of conservation management (national parks, nature reserves, flora reserves, voluntary conservation agreements and property agreements, if perpetual), and particularly those which are highly cleared, are priorities for conservation or restoration.

BRIGALOW BELT SOUTH

Landscape-scale conservation

There are 106 landscapes in the NSW portion of the Brigalow Belt South Bioregion (NPWS in prep). Four low-ruggedness landscapes dominate the bioregion, occupying 49.44% of the area. Specifically these are: landscape 436 (1,100,200.00 ha or 20.64% of the bioregion), landscape 399 (588,200.00 ha or 11.03%), landscape 389 (484,700.00 ha or 9.09%) and landscape 83 (462,700.00 ha or 8.68%). The majority of the remaining landscapes each occupy less than 1% of the bioregion.

Conservation at the landscape scale, however, does not approach any measure of comprehensiveness for any but 5 of the 106 landscapes in the bioregion.

Of the 106 landscapes found within the bioregion, less than half (43) are represented in one or more of the management mechanisms surveyed. Only 6 of these landscapes (5 of which are in national parks and nature reserves) have more than 20% of their bioregional area conserved within these management mechanisms. Twenty-five of the 43 landscapes are represented in more than one mechanism. What this means is that conservation mechanisms and, in this case, private land conservation in particular, is generally focussing on the same landscapes as are included in the reserve (national park/nature reserve and flora reserve) system, but since the overall level of representation of landscapes within the reserve system is relatively small, this contribution is important.

National parks and nature reserves

Most conservation management in the bioregion occurs through national parks and nature reserves (*NPW Act 1974*), both in terms of the area incorporated and the variety of landscapes covered. Nevertheless, the proportion of most landscapes included is relatively small, and only 39 landscapes and a total area of 133,975.47 ha or 2.51% of the bioregional area is included in this management program. Of these 39 landscapes, only 5 have greater than 20% of their area represented in the system of national parks and nature reserves, although 3 high-ruggedness landscapes (100% of landscape 561, 57.17% of landscape 556 and 83.17% of landscape 420) have greater than 50% of their area included in this system.

Voluntary conservation agreements

Two low-ruggedness landscapes (landscape 436 and landscape 389) are represented in the 2 voluntary conservation agreements in the bioregion. These are also represented within the reserve program and other management mechanisms although even in combination less than 10% of each of these landscapes is managed for biodiversity.

Profiles of Landscapes 436, 399, 389 and 83

Landscape 436 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion BBS24 – Pilliga.

Landscape 399 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion BBS25 – Liverpool Plains.

Landscape 389 is an area of low ruggedness with a dominant geology of inland plain sediments occurring in subregion BBS23 – Pilliga Outwash.

Landscape 83 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion BBS22 – Northern Outwash.

Profiles of Landscapes 561, 556 and 420

Landscape 561 is an area of high ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion BBS24 – Pilliga.

Landscape 556 is an area of high ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and meta-sediments occurring in subregion BBS24 – Pilliga.

Landscape 420 is an area of high ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and meta-sediments occurring in subregion BBS25 – Liverpool Plains.

Profiles of Landscapes 312, 87 and 391

Landscape 312 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion BBS22 – Northern Outwash.

Landscape 87 is an area of low ruggedness with a dominant geology of inland plain sediments occurring in subregion BBS22 – Northern Outwash.

Landscape 391 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion BBS25 – Liverpool Plains.

Profiles of Landscapes 99, 389, 436, 598 and 602

Landscape 99 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion BBS21 – Northern Basalts.

Landscape 389 is an area of low ruggedness with a dominant geology of inland plain sediments occurring in subregion BBS23 – Pilliga Outwash.

Landscape 436 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion BBS24 – Pilliga.

Landscape 598 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion BBS27 – Talbragar Valley.

Landscape 602 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion BBS27 – Talbragar Valley.

Wildlife refuges

Twenty-one landscapes overlap wildlife refuges. However, most of these have less than 1% of their bioregional area in a refuge. Since wildlife refuges are not represented in national parks, nature reserves or flora reserves, this contribution to the range of landscapes under some formalised conservation management is important, even though management under a wildlife refuge is not guaranteed in perpetuity. Three landscapes protected under the wildlife refuge program are not found in the system of national parks and nature reserves. These are:

- Landscape 312 with 235.78 ha or 7.37% of its bioregional area;
- Landscape 87 with 941 98 ha or 0.45% of its bioregional area; and
- Landscape 391 with 195.75 ha or 0.17% of its bioregional area.

Flora reserves

Five low-ruggedness landscapes (0.07% of landscape 99, 0.54% of landscape 389, 0.11% of landscape 436, 0.12% of landscape 598 and 0.02% of landscape 602) are represented within flora reserves. Each is also represented in national parks and nature reserves and 3 are also represented in other formal conservation areas.

Property agreements

Ten low to moderate ruggedness landscapes (0.04% of landscape 436, 2.24% of landscape 410, 0.27% of landscape 398, 0.01% of landscape 399, 0.43% of landscape 394, 0.03% of landscape 573, 0.03% of landscape 456, 0.92% of landscape 658, 0.02% of landscape 391 and 0.01% of landscape 552) are represented in the conservation zones of property agreements. All are represented in other formal conservation areas.

Conservation and clearing

Forty-eight of the 106 landscapes are more than 70% cleared (19 are 70-90% cleared, 15 are 91-99% cleared and 14 are 100% cleared) of their native canopy. Only 12 of these are represented in conservation areas.

BROKEN HILL COMPLEX

Landscape-scale conservation

The Broken Hill Complex Bioregion is composed of 36 landscapes (Mitchell in prep). Of these, 8 are endemic to the bioregion. The size of these landscapes ranges from the Sturt Dunes landscape, which occupies the smallest area of the bioregion (1.36 ha or 0.000036%), to the Barrier Downs landscape, the largest area, which occupies almost 23% (861,133 ha) of the bioregion.

Landscapes are not comprehensively reserved within the bioregion. Less than a third of the landscapes of the Broken Hill Complex Bioregion are represented in national parks or nature reserves. An additional landscape is represented in the wildlife refuges in the bioregion.

National parks and nature reserves

Eleven of the 36 landscapes are represented in national parks and nature reserves. However only 2 of these have more than 20% of their bioregional area included in reserves.

Wildlife refuges

Four landscapes (968.82 ha or 0.20% of the Barrier Alluvial Plains landscape, 6,562.17 ha or 0.76% of the Barrier Downs landscape, 92.18 ha or 7.34% of the Lower Darling Lakes and Swamps landscape and 7,892.81 ha or 3.19% of the Scopes Sandplains landscape) occur in the 2 wildlife refuges in the bioregion. Of these, the Barrier Downs landscape is not represented in reserves, while the Scopes Sandplains landscape is relatively better represented in wildlife refuge than in the reserves (7.94 ha or 0.03% of its bioregional area is reserved compared to 7892.81 ha or 3.19% of its bioregional area in the wildlife refuge program).

Historic site

The Mootwingee-Wonnaminta Ranges landscape is represented in the Mutawinji historic site. This landscape is also represented in the reserve (national park and nature reserve) program.

Conservation and clearing

Only 300 ha of the Broken Hill Complex Bioregion is identified as cleared of its native vegetation canopy. This clearing is concentrated within 2 of the 36 landscapes, the Lower Darling Channels and Floodplains (200 ha or 7.80% of its area cleared) and the Scopes Sandplains (100 ha or 0.04% of its area cleared). Of these, the Lower Darling Channels and Floodplains landscape is not represented in reserves or other conservation tenures.

CHANNEL COUNTRY

Landscape-scale conservation

Although the Channel Country Bioregion is composed of 14 landscapes (Mitchell in prep), almost 90 per cent of the bioregion is dominated by 5 landscapes. These are:

- the Tibooburra Downs landscape occupying 433,730.44 ha or 30.34% of the bioregion;
- the Tibooburra Tablelands landscape occupying 244,165.93 ha or 17.08% of the bioregion;
- the Bulloo Littoral and Lunettes landscape, occupying 242,539.58 ha or 16.97% of the bioregion;
- the Tibooburra Alluvial Plains landscape, occupying 178,746.80 ha or 12.50% of the bioregion; and
- the Bulloo Channels and Floodouts landscape, occupying 175,111.96 ha or 12.25% of the bioregion.

The size of landscapes in the bioregion ranges from the Tibooburra Fresh Lakes and Swamps landscape, which occupies the smallest area at 1.29 ha or 0.0001% of the bioregion, to the Tibooburra Downs landscape, the largest, which occupies about 30.34% or 433,730 ha of the bioregion.

National parks and nature reserves

Just under half of the landscapes (6) occur in national parks and nature reserves. Two of these, the Tibooburra Downs landscape (with 108,530.88 ha or 25.02% of its bioregional area) and the Tibooburra Tablelands landscape (with 56,174.87 ha or 23.01% of its bioregional area) have greater than 20% of their bioregional area reserved.

Wildlife refuges

While the length and scope of management of lands in wildlife refuges is likely to be variable, the wildlife refuge program in the Channel Country Bioregion contains a marginally wider representation of landscapes than in national parks or nature reserves. Nine of the bioregional landscapes – Tibooburra Downs, Tibooburra Tablelands, Bulloo Littoral and Lunettes, Tibooburra Alluvial Plains, Bulloo Channels and Floodouts, Tibooburra Sandplains, Tibooburra Ranges, Bulloo Salt Lakes and Playas and the Bulloo Linear Dunes – are represented in wildlife refuges. Four of these landscapes are also reserved and 3 are also represented in the Aboriginal area but 2 are not represented in any other conservation mechanism. The area of 3 landscapes – Tibooburra Alluvial Plains (18.32% of the bioregional area of landscape in wildlife refuge compared to 9.55% in reserves), Tibooburra Sandplains (21.26% bioregional area of landscape in wildlife refuge compared to 11.81% in reserves) and Tibooburra Ranges (3.71% in wildlife refuge compared to 1.22% in reserves) included in wildlife refuges is greater than the area conserved in reserves.

Aboriginal area

Three bioregional landscapes occur in the Pindera Downs Aboriginal Area in the bioregion (572.25 ha or 0.23% of the Tibooburra Tablelands landscape, 2,259.88 ha or 0.93% of the Bulloo Littoral and Lunettes landscape and 6,555.02 ha or 3.74% of the Bulloo Channels and Floodouts landscape). Two of these – the Bulloo Littoral and Lunettes and the Bulloo Channels and Floodouts landscapes – are also represented in wildlife refuges but not in the reserves, with the Aboriginal area conserving the greatest area of the Bulloo Channels and Floodouts landscape.

Conservation and clearing

The only quantitative information on landscape condition available is on the presence or absence of native canopy and its representation in management regimes that have some conservation focus or capacity to conserve (State Conservation Monitoring Project). The native canopy of the vegetation of the Channel Country Bioregion has been identified as entirely intact. Despite this, protection of landscapes against future change in the bioregion is not comprehensive, with less than half represented in reserves and an additional 3 achieving only some representation in wildlife refuges or in the Aboriginal area.

COBAR PENEPLAIN

Landscape-scale conservation

Eighty-one landscapes occur in the Cobar Peneplain Bioregion (NPWS in prep). Two low ruggedness landscapes dominate the bioregion. These are Landscape 372 (occupying 826,400.00 ha or 11.27% of the bioregional area), and Landscape 579 (occupying 675,700.00 ha of the bioregion or 9.21% of the bioregional area). Almost three-quarters of the remaining landscapes individually occupy less than 1% of the bioregional area. Just over half (45) of the bioregion's landscapes are represented in one or more of the areas managed for conservation.

National parks and nature reserves

Thirty-two of the 81 landscapes have some representation in national parks and nature reserves. Only 5 (some of which are relatively small) of the landscapes have greater than 20% of their area included in this reserve system. These are:

- Landscape 493 with 100.00 ha or 100% of its bioregional area; -
- Landscape 480 with 56.85 ha or 56.85% of its bioregional area; -
- Landscape 479 with 1461.54 ha or 48.72% of its bioregional area;
- Landscape 364 with 391.10 ha or 23.01% of its bioregional area; and -
- Landscape 824 with 6014.43 ha or 24.75% of its bioregional area. -

The dominant landscapes of the bioregion – Landscape 372 (with 794.19 ha or 0.10% of its bioregional area) and Landscape 579 (with 863.32 ha or 0.13% of its bioregional area) – have only limited representation in the reserve system.

Wildlife refuges

Twenty-five of the bioregional landscapes are represented in wildlife refuges on private properties. Of these, 100% of two landscapes, 831 and 840 (both very small, about 100 ha each), are wholly contained within refuges, and 53.49% of landscape 506 is contained in a refuge. Ten landscapes found in wildlife refuges are not represented in the reserve program. These include:

- Landscape 754 with 8,716.94 ha or 19.81% of its bioregional area; -
- Landscape 492 with 5,862.33 ha or 1.75% of its bioregional area; -
- Landscape 755 with 5,146.78 ha or 7.16% of its bioregional area;
- Landscape 624 with 676.05 ha or 0.38% of its bioregional area; -
- Landscape 384 with 353.59 ha or 2.17% of its bioregional area; -
- Landscape 506 with 213.96 or 53.49% of its bioregional area;
- Landscape 581 with 130.51 ha or 0.07% of its bioregional area; -
- Landscape 820 with 106.92 ha or 1.37% of its bioregional area; and -
- Landscape 840 and Landscape 831, both up to 100 ha and 100%. -

Flora reserve

Three landscapes (Landscape 577 with 1063.36 ha or 1.14% of its bioregional area, Landscape 615 with 169.73 ha or 0.09% of its bioregional area and Landscape 579 with 470.60 ha or 0.07% of its bioregional area) are conserved within the flora reserve. The 1063.36 ha of landscape 577 is not represented in national parks and nature reserves.

Profile of Landscapes 372 and 579

Landscape 372 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion cp3 – Canbelego Downs).

Landscape 579 is an area of low ruggedness with a dominant geology of continental colluvial/ residual deposits occurring in subregion cp4 – Nymagee-Rankins Springs.

Profile of Landscapes 493, 480, 479, 364 and 824

Landscape 493 is an area of low ruggedness with a dominant geology of sedimentary (calcareous) occurring in subregion cp3 – Canbelego Downs.

Landscape 480 is an area of high ruggedness with a dominant geology of continental colluvial/ residual deposits occurring in subregion CP3 – Canbelego Downs.

Landscape 479 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion CP3 – Canbelego Downs.

Landscape 364 is an area of moderate ruggedness with a dominant geology of continental colluvial/ residual deposits occurring in subregion CP3 – Canbelego Downs

Landscape 824 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion CP5 – Lachlan Plains.

Profile of Landscapes 831, 840 and 506

Landscape 831 is an area of moderate ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion CP5 – Lachlan Plains.

Landscape 840 is an area of moderate ruggedness with a dominant geology of western floodplains (active) occurring in subregion CP5 – Lachlan Plains.

Landscape 506 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion CP2 – Barnato Downs.

Profile of Landscapes 384 and 820

Landscape 384 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion CP3 – Canbelego Downs.

Landscape 820 is an area of low ruggedness with a dominant geology of inland sand dunes occurring in subregion CP5 – Lachlan Plains.

Profile of Landscapes 615 and 577

Landscape 615 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion CP4 – Nymagee-Rankins Springs.

Landscape 577 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion CP4 – Nymagee-Rankins Springs.

Profile of Landscapes 624, 808, 581 and 812

Landscape 624 is an area of low ruggedness with a dominant geology of acid metamorphics occurring in subregion CP4 – Nymagee-Rankins Springs.

Landscape 808 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion CP5 – Lachlan Plains.

Landscape 581 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion CP4 – Nymagee-Rankins Springs.

Landscape 812 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion CP5 – Lachlan Plains.

Profile of Landscapes 500, 489 and 492

Landscape 500 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion CP2 – Barnato Downs.

Landscape 489 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion CP2 – Barnato Downs.

Landscape 492 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion CP2 – Barnato Downs.

Profile of totally cleared Landscapes 612, 830, 831, and 840

Landscape 612 is a 300 ha area of low ruggedness with a dominant geology of ultra basic igneous intrusives occurring in subregion CP4 – Nymagee – Rankins Springs.

Landscape 830 is a 100 ha area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion CP5 – Lachlan Plains.

Landscape 831 is a 100 ha area of moderate ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion CP5 – Lachlan Plains.

Profiles of highly to extremely cleared Landscapes 581, 624, 754, 755, 760, 777, 802, 820 and 823

Landscape 581 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion CP4 – Nymagee-Rankins Springs.

Landscape 624 is an area of low ruggedness with a dominant geology of acid metamorphics occurring in subregion CP4 – Nymagee-Rankins Springs.

Landscape 754 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion CP5 – Lachlan Plains.

Landscape 755 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion CP5 – Lachlan Plains.

Landscape 760 is an area of low ruggedness with a dominant geology of inland plain sediments occurring in subregion CP5 – Lachlan Plains.

Landscape 777 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion CP5 – Lachlan Plains.

Landscape 802 is an area of moderate ruggedness with a dominant geology of inland plain sediments occurring in subregion CP5 – Lachlan Plains.

Landscape 812 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion CP5 – Lachlan Plains.

Landscape 820 is an area of low ruggedness with a dominant geology of inland sand dunes occurring in subregion CP5 – Lachlan Plains.

Landscape 823 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion CP5 – Lachlan Plains.

Property agreements

Although 10 landscapes are represented in the conservation zone of property agreements, less than 1% of their bioregional area is represented within this program. Five landscapes are represented in property agreements which are not included in national parks and nature reserves. These include:

- Landscape 624 with 286.33 ha or 0.16% of its bioregional area;
- Landscape 808 with 65.09 ha or 0.83% of its bioregional area;
- Landscape 581 with 80.36 ha or 0.04% of its bioregional area;
- Landscape 577 with 92.53 ha or 0.10% of its bioregional area; and
- Landscape 812 with 127.55 ha or 0.44% of its bioregional area.

Historic site

Three landscapes (Landscape 500 with 126.93 ha or 0.03% of its bioregional area; Landscape 489 with 264.12 ha or 0.10% of its bioregional area and Landscape 492 with 974.04 ha or 0.29% of its bioregional area) are conserved within the Mt Grenfell Historic Site. The 974 ha of one of these, Landscape 492, is not represented in national parks and nature reserves.

Conservation and clearing

About one-third (2,298,800 ha or 31.34%) of the Cobar Peneplain Bioregion has been cleared of its native canopy. About two-thirds of the landscapes have experienced this type of clearing (other forms of clearing, eg understorey and loss of condition, are not yet detectable at the all of state scale). Four relatively small low to moderate ruggedness landscapes of varying geology (612, 830, 831, 840) are totally cleared. Eleven landscapes (448, 581, 604, 697, 756, 760, 769, 777, 803, 812, 820) are extremely cleared with 70-90% of their bioregional area experiencing this degree of clearing and 6 landscapes (624, 646, 754, 755, 802, 823) are highly cleared with 50-70% of their native canopy absent. Five landscapes (351, 517, 576, 579, 622) have greater than 30% of their native canopy cleared.

Of those high to extremely cleared landscapes 3 landscapes (760, 802, 823) are represented in national parks and nature reserves. A wider range of 9 landscapes has representation in wildlife refuges. These are landscapes: 581, 624, 754, 755, 760, 777, 802, 820, 823. Three of these landscapes (823, 614, 812) are also represented in the conservation zones of property agreements. All landscapes lacking at least minimal representation in high security conservation (national parks, nature reserves and flora reserves) are a priority for conservation. The remaining vegetated areas of highly cleared landscapes are a priority for conservation action including restoration, particularly if further clearing of the unprotected areas of these landscapes is likely.

DARLING RIVERINE PLAINS

Landscape-scale conservation

The Darling Riverine Plains Bioregion is composed of 67 landscapes (NPWS in prep). One landscape, Landscape 51, dominates the bioregion, occupying an area of 3,788,000.00 ha or 40.34% of the bioregion. Another landscape, Landscape 311, occupies a further 18.92% of the bioregion and 10 other landscapes occupy between one and 5% of the bioregional area.

Landscapes are not comprehensively reserved (as national parks or nature reserves) or represented in other conservation mechanisms. Seventeen of the 67 landscapes are represented in the reserve system. Wildlife refuges and property agreements add to the variety of landscapes included in some form of conservation management regime. The one flora reserve and one voluntary conservation agreement expand the area of one landscape managed, but only one landscape, Landscape 762, has more than 20% (31.34% or 12,347.96 ha) of its area represented in conservation areas and the chief contribution is made by the less secure management of wildlife refuges.

National parks and nature reserves

Seventeen of the 67 landscapes are represented in national parks and nature reserves. This includes a small area of each of the 2 dominant landscapes, Landscape 51 and 311 (708.50 ha or 0.02% and 2,697.39 ha or 0.15% respectively). Neither has more than 20% represented in the reserve system.

Voluntary conservation agreement

The one voluntary conservation agreement increases the area of Landscape 51 (18.98 ha) under conservation management in the bioregion.

Profiles of Landscapes 51 and 311

Landscape 51 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion DRP4 – Macintyre – Weir Fan, Castlereagh-Barwon.

Landscape 311 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion DRP5 – Bogan-Macquarie.

Profile of Landscape 762

Landscape 762 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion DRP9 – Great Darling Anabranch.

Profiles of Landscapes 375, 405, 152, 120, 308, 309, 310, 516, 520, 513, 512 and 119

Landscape 375 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion DRP5 – Bogan-Macquarie.

Landscape 405 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion DRP5 – Bogan-Macquarie.

Landscape 152 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion DRP4 – Macintyre – Weir Fan, Castlereagh-Barwon.

Landscape 120 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion DRP3 – Warrambool-Moonie.

Landscape 308 is an area of low ruggedness with a dominant geology of inland plain sediments occurring in subregion DRP6 – Louth Plains.

Landscape 309 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion DRP6 – Louth Plains.

Landscape 310 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion DRP6 – Louth Plains.

Landscape 516 is an area of low ruggedness with a dominant geology of inland sand dunes occurring in subregion DRP7 – Wilcannia Plains.

Landscape 520 is an area of low ruggedness with a dominant geology of inland plain sediments occurring in subregion DRP7 – Wilcannia Plains.

Landscape 513 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion DRP7 – Wilcannia Plains.

Landscape 512 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion DRP7 – Wilcannia Plains.

Landscape 119 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion DRP3 – Warrambool-Moonie.

Profiles of Landscapes 323 and 347

Landscape 323 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion DRP5 – Bogan-Macquarie

Landscape 347 is an area of low ruggedness with a dominant geology of continental colluvial/residual deposits occurring in subregion DRP5 – Bogan-Macquarie

Wildlife refuges

Wildlife refuges add to the landscapes included in conservation mechanisms in the bioregion. Twenty-seven landscapes are representedin the wildlife refuge program. Twelve of these are not reserved and are not represented in other conservation mechanisms. These include:

- Landscape 375 with 55.68 ha or 2.23% of its bioregional area; -
- Landscape 405 with 14.66 ha or 0.10% of its bioregional area;
- Landscape 152 with 1369.36 ha or 0.95% of its bioregional area; -
- Landscape 120 with 1375.98 ha or 16.99% of its bioregional area; -
- Landscape 308 with 1989.92 ha or 5.77% of its bioregional area;
- Landscape 309 with 2160.24 ha or 1.57% of its bioregional area; -
- Landscape 310 with 3475.36 ha or 3.20% of its bioregional area; -
- Landscape 516 with 4161.96 ha or 6.51% of its bioregional area;
- Landscape 520 with 6654.79 ha or 15.16% of its bioregional area; -
- Landscape 513 with 15098.05 ha or 9.85% of its bioregional area; -
- Landscape 512 with 32681.03 ha or 16.37% of its bioregional area; and
- Landscape 119 with 46061.99 ha or 9.10% of its bioregional area. -

Although also represented in the reserve system, a relatively large proportion of Landscape 762 (10,391.38 ha or 26.37%) is represented in the wildlife refuge program.

Flora reserve

A small area (14.62 ha) of one landscape, Landscape 51 (already profiled), is included in the flora reserve.

Property agreements

Three landscapes are represented in the conservation zone of property agreements. These are:

- Landscape 311 (already profiled), 341.55 ha or 0.02% of its bioregional area;
- Landscape 323, 59.55 ha or 0.02% of its bioregional area; and
- Landscape 347, 20.01 ha or 0.16% of its bioregional area.

Landscape 347 is not included in any other conservation regime in the bioregion.

Conservation and clearing

Almost half (41% or 3,850,700 ha) of the Darling Riverine Plains Bioregion has been cleared of its native canopy vegetation. Clearing is not uniformly distributed across all landscapes, and 21 of the 68 landscapes have not experienced this type of clearing. Five landscapes have experienced extreme levels of clearing of greater than 70% of their original area. These are:

- Landscape 416 with 600 ha or 75.00% of its area cleared;
- Landscape 332 with 2,800 ha 75.68% of its area cleared; -
- Landscape 350 with 8,000 ha or 78.43% of its area cleared; -
- Landscape 536 with 700 ha or 87.50% of its area cleared; and
- Landscape 74 with 4,300 ha or 87.76% of its area cleared. -

A further 8 landscapes are highly cleared, with between 50 and 70% of their area cleared of native canopy and an additional 2 have greater than 30% of their area cleared of native canopy.

Of those high to extremely cleared landscapes, 3 have some representation in nature reserves in the bioregion (311, 51 and 54), 2 are included in wildlife refuges (311 and 51) and 2 (311 and 347) in the conservation zone of property agreements. All landscapes lacking at least minimal representation in high-security conservation (national parks, nature reserves and flora reserves) are a priority for conservation. The remaining vegetated areas of highly cleared landscapes are a priority for conservation action, including restoration, particularly if further clearing activity within unprotected areas of these landscapes is likely.

MULGA LANDS

Landscape-scale conservation

The Mulga Lands Bioregion is composed of 35 landscapes, all of which are also found in other bioregions, except one, the Paroo-Warrego/Mt Murchison landscape, which is endemic to the NSW area of the bioregion (Mitchell in prep).

The size of landscapes in the bioregion is varied, ranging from the Scopes Alluvial Plains landscape, which occupies the smallest area of the bioregion (6.82 ha or 0.0001%), to the largest landscape, the Paroo-Warrego Sandplains, which occupies almost 17.31% or 1,134,649 ha of the bioregion.

Landscapes in the Mulga Lands Bioregion are not comprehensively reserved or conserved, with less than a third achieving representation in the reserve (national parks and nature reserves) system and none achieving greater than 20% or even 10% reservation.

National parks and nature reserves

Eleven of the 36 Mulga Lands landscapes occur in national parks and nature reserves, but all are less than 10% represented in this program. The endemic Paroo-Warrego/Mt Murchison landscape is not included in the reserve system.

Wildlife refuges

Wildlife refuges include 15 landscapes, 9 of which are also included in the reserve system, while 6 are not. The Mid Darling Alluvial Plains landscape has 31% of its bioregional area included in wildlife refuges and the endemic Paroo-Warrego/Mt Murchison landscape has 13.21 % of its bioregional area included in wildlife refuges. The wildlife refuge program is important for the conservation of these 2 landscapes, as they are not protected under any of the other surveyed mechanisms.

Conservation and clearing

While a relatively small proportion of the Mulga Lands Bioregion has been cleared of its native canopy (about 16,800 ha or 0.26% of the bioregional area), this type of clearing is concentrated in 10 of the landscapes, with the majority of clearing occurring in 5 of these. The Paroo-Warrego Channels and Floodouts landscape has had the greatest area cleared, 6,400 ha or 0.75% of its area, while 2,700 ha or almost 16% of the Mid Darling Channels and Floodplains landscape has been cleared. Less than 5 per cent of each of these landscapes occurs in conservation tenures in the bioregion and the Mid Darling Channels and Floodplains landscape has no representation in reserves.

Clearing of the native canopy is not indicated in the one endemic landscape of the bioregion, the Paroo-Warrego/Mt Murchison landscape, but this does not guarantee that the understorey is not undergoing significant degradation.

MURRAY DARLING DEPRESSION

Landscape-scale conservation

The Murray Darling Depression Bioregion is composed of 74 landscapes (Mitchell in prep). Nine landscapes are endemic to the bioregion: Ivanhoe-Nangara Fresh Lakes and Swamps, Ivanhoe-Nangara Isolated Bedrock, Ivanhoe-Nangara Relic Lakes, Lower Darling Salt Lakes and Playas, Mallee Cliffs Relic Lakes, Mallee Cliffs Salt Lakes and Playas, Mungo-Marona Dunes, Sayers Lake Complex and Scotia Dunes.

The size of these landscapes varies from the Barnato Linear Dunes landscape, which occupies the smallest area of the bioregion (76.31 ha or 0.0010%), to the largest, the Ivanhoe-Nangara Sandplains landscape, which occupies 29.87% (2,397,272 ha) of the bioregion. The majority of landscapes (59 out of 74) occupy less than 1% of the bioregional area.

Landscapes in the Murray Darling Depression Bioregion are not comprehensively reserved, with only one of 74 achieving representation in the reserve system, which occupies about 20% of the bioregion. This is the Gilgunnia-Broken Ranges landscape and the area reserved is in fact very small at only 20.87 ha (19.44% of the landscape). Only 3 landscapes achieve a combined (all surveyed mechanisms accounted for) conservation status of greater than 20%. These are:

- the Scotia Dunes landscape with 30.63% of its bioregional area;
- the Waranary-Yathong Ranges landscape with 21.13% of its bioregional area; and

- the Lower Darling Lakes and Swamps landscape with 31.85% of its bioregional area.

Three of the 7 landscapes that are endemic to the bioregion are minimally represented in reserves. These are the Ivanhoe-Nangara Fresh Lakes and Swamps, Ivanhoe-Nangara Isolated Bedrock and Mungo-Marona Dunes.

The impact of clearing on some individual landscapes has been high, with over 50% of 8 landscapes cleared of their native canopy and only 2 of these minimally reserved. Almost a quarter of the area of one of the endemic landscapes is cleared and it is not reserved.

National parks and nature reserves

Only 22 of the 74 landscapes of the bioregion are represented in the system of national parks and nature reserves. Only one landscape, the Waranary-Yathong Ranges landscape, is more than 20% reserved. A small area of the Gilgunnia-Broken Ranges landscape (20.87 ha) gives it a reservation status of 19.44%.

Two of the 9 endemic landscapes, Mungo Marona Linear Dunes (minimally, at 1.17%) and Ivanhoe-Nangara Fresh Lakes and Swamps (3.35%), are represented in reserves.

Wildlife refuges

Nineteen of the 74 landscapes occur in the 9 wildlife refuges in the bioregion. A significant proportion of 2 landscapes, the Lower Darling Lakes and Swamps landscape (with 6,814.52 ha or 31.85% of its bioregional area) and the Scotia Dunes landscape at 30.63% (19,708.68 ha), occur in wildlife refuges. The latter landscape is endemic to the bioregion. Nine landscapes not represented in reserves or flora reserves can be found in the wildlife refuges of the bioregion. These are:

- the Mid Darling Lakes and Swamps with 34.03 ha or 0.40% of the landscape;
- the Mt Grenfell Complex with 109.15 ha or 1.43% of the landscape;
- the Bokara Hills with 310.42 ha or 2.14% of the landscape;
- the Mid Darling Alluvial Plains with 1518.01 ha or 9.61% of the landscape;
- the Lower Darling Channels and Floodplain with 2074.59 ha or 4.98% of the landscape;
- the Lower Darling Alluvial Plains with 4606.64 ha or 4.73% of the landscape;
- the Scotia Groundwater Basins with 5439.98 ha or 8.93% of the landscape;
- the Lower Darling Lakes and Swamps with 6814.52 ha or 31.85% of the landscape; and
- the Scotia Dunes with 19708.68 ha or 30.63% of the landscape.

Flora reserves

Two landscapes (the Murrumbidgee Channels and Floodplains landscape with 31.15 ha or 0.32 % of the landscape and the Murray Channels and Floodplains landscape with 45.30 ha or 0.48% of the landscape) are represented in the Peacock Creek Flora Reserve. Although the Murray Channels and Floodplains landscape is included in the wildlife refuge program, it is not included in the national park and nature reserve system.

Conservation and clearing

A relatively small proportion of the bioregion is indicated as being cleared of its native canopy vegetation. Some 539,200 ha or 6.72% of the bioregion has experienced this form of clearing (other forms of clearing are not yet detectable at the state scale). Although a relatively small proportion of the bioregion is cleared, it has been spread across more than half of the landscapes. Six landscapes – the Murrumbidgee Sandplains, Lachlan Sandplains, Murrumbidgee Depression Plains, Cocoparra Ranges and Footslopes, Murrumbidgee Lakes, Swamps and Lunettes and the Murray Sandplains landscapes – have experienced extreme clearing with between 70 and 99 per cent of their area cleared. An additional 2 landscapes – the Murrumbidgee Scalded Plains and the Lachlan Depression Plains landscapes – have been highly cleared, with between 50 and 70 per cent of the landscape cleared. Three landscapes have between 30 and 50 per cent of their bioregional area cleared. These are the Scotts Craig Hills, Shepherds Hill and Footslopes and the Lachlan Channels and Floodplains landscapes.

Of those highly to extremely cleared landscapes, 3 are represented in national parks and nature reserves – the Scotts Craig Hills, Lachlan Channels and Floodplains and Lachlan Sandplains landscapes. The Lachlan Channels and Floodplains is also represented in wildlife refuges. Landscapes lacking at least minimal representation in high security conservation zones (national parks, nature reserves and flora reserves) are a priority for conservation. The remaining vegetated areas of highly cleared landscapes are a priority for conservation action, including restoration, particularly if further clearing occurs in the unprotected areas of these landscapes.

NANDEWAR

Landscape-scale conservation

There are 70 landscapes in the NSW portion of the Nandewar Bioregion (NPWS in prep).

Of the 70 landscapes, just over half (36) are represented in the conservation mechanisms surveyed. Of these, 23 are represented in one mechanism only, and where this occurs the proportion of landscapes conserved is generally small. Six landscapes (324, 317, 339, 336, 344, 386) do achieve greater than 20% representation and all lie only in national parks or nature reserves.

National parks and nature reserves

Twenty-nine of the 70 landscapes lie in national parks and nature reserves. The ruggedness and geology of these landscapes varies. The subregion of origin of the landscapes are the Peel, Kaputar and Nandewar, Northern Complex subregions. The 6 landscapes with more than 20% of their NSW bioregional area in parks and reserves are:

- Landscape 324 with 1,867.71 ha or 23.06% of its bioregional area;
- Landscape 317 with 15,885.44 ha or 51.74% of its bioregional area;
- Landscape 339 with 7,262.84 ha or 59.05% of its bioregional area;
- Landscape 336 with 3,281.82 ha or 82.05% of its bioregional area;
- Landscape 344 with 4,896.64 ha or 84.42% of its bioregional area; and
- Landscape 386 with 100.00 ha or 100.00% of its bioregional area.

Wildlife refuges

Eleven landscapes (137, 109, 126, 168, 101, 173, 110, 102, 154, 106 and 111) are represented in wildlife refuges, although the greatest proportion of a landscape represented by this program is 1.93 %. Four of these landscapes (109, 126,173 and 101) are not represented in the national park and nature reserves of the bioregion.

- Landscape 137 with 0.93 ha or <0.01% of its bioregional area; -
- Landscape 109 with 0.96 ha or 0.01% of its bioregional area;
- Landscape 126 with 0.98 ha or 0.06 %of its bioregional area; -
- Landscape 168 with 3.32 ha or 0.03 %of its bioregional area; -
- Landscape 101 with 4.26 ha or 0.03 %of its bioregional area;
- Landscape 173 with 27.92 ha or 0.20 %of its bioregional area; -
- Landscape 110 with 137.78 ha or 1.51% of its bioregional area; -
- Landscape 102 with 208.28 ha or 0.16 %of its bioregional area;
- Landscape 154 with 392.08 ha or 0.22% of its bioregional area; -
- Landscape 106 with 427.48 ha or 0.50 %of its bioregional area; and -
- Landscape 111 with 686.49 ha or 1.93% of its bioregional area. -

Profiles of Landscapes 324, 317, 339, 336, 344 and 386

Landscape 324 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NAN3 – Kaputar.

Landscape 317 is an area of moderate ruggedness with a dominant geology of basic/ intermediate igneous and associated sediments and metasediments occurring in subregion NAN3 – Kaputar.

Landscape 339 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NAN3 – Kaputar.

Landscape 336 is an area of high ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NAN3 – Kaputar.

Landscape 344 is an area of high ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NAN3 – Kaputar.

Landscape 386 is an area of high ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NAN3 – Kaputar.

Profiles of Landscapes 137, 109, 126, 168, 101, 173, 110, 102, 154, 106 and 111

Landscape 137 is an area of moderate ruggedness with a dominant geology of sedimentary - (coarse grain) occurring in subregion NAN1 – Nandewar, Northern Complex. -

Landscape 109 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NAN1 – Nandewar, Northern Complex. -

Landscape 126 is an area of moderate ruggedness with a dominant geology of western alluvials - (inactive) occurring in subregion NAN1 – Nandewar, Northern Complex. -

Landscape 168 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN2 – Inverell Basalts. -

Landscape 101 is an area of low ruggedness with a dominant geology of western alluvials - (inactive) occurring in subregion NAN1 – Nandewar, Northern Complex. -

Landscape 173 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NAN2 – Inverell Basalts. -

Landscape 110 is an area of moderate ruggedness with a dominant geology of acid igneous - intrusives occurring in subregion NAN1 – Nandewar, Northern Complex. -

Landscape 102 is an area of low ruggedness with a dominant geology of sedimentary - (mixed grain) occurring in subregion NAN1 – Nandewar, Northern Complex. -

Landscape 154 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion NAN2 – - Inverell Basalts. -

Landscape 106 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NAN1 – Nandewar, Northern Complex. -

Landscape 111 is an area of moderate ruggedness with a dominant geology of sedimentary - (mixed grain) occurring in subregion NAN1 – Nandewar, Northern Complex. -

Landscape 110 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NAN1 – Nandewar, Northern Complex.

Profiles of Landscapes 232 and 239

Landscape 232 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NAN4 – Peel.

Landscape 239 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NAN4 – Peel.

Profiles of Landscapes 231, 229, 233, 232 and 235

Landscape 231 is an area of low ruggedness with a dominant geology of sedimentary (fine grain– non calcareous) occurring in subregion NAN4 – Peel.

Landscape 229 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion NAN4 – Peel.

Landscape 233 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN4 – Peel.

Landscape 232 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NAN4 – Peel.

Landscape 235 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NAN4 – Peel.

State recreation area

Only one landscape, Landscape 110, with 72.5 ha or 80% of the area of the landscape, occurs in state recreation areas. A larger area of this landscape is represented in national parks and nature reserves and in the wildlife refuge program.

Flora reserves

A relatively small proportion of 2 landscapes is represented in flora reserves: 10.65 ha or less than 0.01% of landscape 232 and 38.12 ha or 0.02% of landscape 239. Small areas of Landscape 232 are also represented in the conservation zone of property agreements and in national parks and nature reserves. Landscape 239 is also represented in national parks and nature reserves.

Property agreements

Five landscapes (231, 229, 233, 232 and 235) are represented in property agreements in the NSW portion of the bioregion. These are:

- Landscape 231 with 3.48 ha or <0.01% of its bioregional area;
- Landscape 229 with 7.41 ha or 0.01% of its bioregional area;
- Landscape 233 with 13.47 ha or 0.02% of its bioregional area;
- Landscape 232 with 16.89 ha or 0.01% of its bioregional area; and
- Landscape 235 with 95.81 ha or 0.12% of its bioregional area.

Two of these (231 and 233) are not represented in the system of national parks and nature reserves. The proportion of each represented is less than 0.12% of the respective landscapes.

Conservation and clearing

A very high proportion, about two-thirds (1,371,100.00 ha or 66.33%), of the Nandewar Bioregion has been cleared of its native vegetation canopy and a large proportion of the landscapes (61 of the 70) have experienced this form of clearing activity. Five landscapes ranging in area from 100 ha to 400 ha have been totally cleared while a further 19 have experienced extreme levels of clearing of greater than 70% of their area. A further 12 landscapes are highly cleared, with greater than 50% of their area cleared, and 14 have greater than 30% of their native canopy cleared.

Of those high to extremely cleared landscapes, eleven (261, 102, 137, 232, 168, 229, 153,154, 198, 316 and 358) are represented in the system of national parks and nature reserves. Eight (109, 102, 126, 137, 168, 173, 154 and 101) are included in wildlife refuges and 4 (232, 229, 233 and 231) are included in property agreements. All landscapes lacking at least minimal representation in high-security conservation tenures (national parks, nature reserves and flora reserves, VCAs and property agreements, if perpetual) are a priority for conservation. The remaining vegetated areas of highly cleared landscapes are a priority for conservation action, including restoration, particularly if further clearing activity within the unprotected areas of these landscapes is likely.

Profiles of the totally cleared Landscapes 136, 139, 164, 220 and 567

Landscape 136 is a 400 ha area of low ruggedness with a dominant geology of sedimentary (calcareous) occurring in subregion NAN1 – Nandewar, Northern Complex.

Landscape 139 is a 300 ha area of moderate ruggedness with a dominant geology of continental colluvial/residual deposits occurring in subregion NAN1 – Nandewar, Northern Complex.

Landscape 164 is a 200 ha area of moderate ruggedness with a dominant geology of sedimentary (calcareous) occurring in subregion NAN1 – Nandewar, Northern Complex.

Landscape 220 is a 200 ha area of moderate ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN2 – Inverell Basalts.

Landscape 567 is a 100 ha area of high ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN4 – Peel.

Profiles of highly to extremely cleared Landscapes 261, 102, 137, 232, 168, 229, 153,154, 198, 316 and 358

Landscape 261 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion NAN4 – Peel.

Landscape 101 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN1 – Nandewar, Northern Complex.

Landscape 102 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NAN1 – Nandewar, Northern Complex.

Landscape 109 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NAN1 – Nandewar, Northern Complex.

Landscape 126 is an area of moderate ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN1 – Nandewar, Northern Complex.

Landscape 137 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NAN1 – Nandewar, Northern Complex.

Landscape 153 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NAN2 – Inverell Basalts.

Landscape 154 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion NAN2 – Inverell Basalts.

Landscape 168 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN2 – Inverell Basalts.

Landscape 173 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NAN2 – Inverell Basalts.

Landscape 198 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion NAN2 – Inverell Basalts.

Landscape 229 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion NAN4 – Peel.

Landscape 231 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion NAN4 – Peel.

Landscape 232 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NAN4 – Peel.

Landscape 233 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN4 – Peel.

Landscape 316 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NAN3 – Kaputar.

Landscape 358 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion NAN3 – Kaputar.

Profiles of Landscapes 526, 245 and 273

Landscape 526 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET3 – Walcha Plateau

Landscape 245 is an area of low ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET7 – Glenn Innes – Guyra Basalts

Landscape 273 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET16 – Eastern Nandewars

Profiles of Landscapes 560, 465, 475, 163, 383, 224 & 285

Landscape 560 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET3 – Walcha Plateau.

Landscape 465 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET8 – Ebor Basalts.

Landscape 475 is an area of low ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET19 – Round Mountain.

Landscape 163 is an area of high ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET11 – Northeast Forest Lands.

Landscape 383 is an area of high ruggedness with a dominant geology of eastern alluvials occurring in subregion NET5 – Wongwibinda Plateau.

Landscape 224 is an area of high ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET11 – Northeast Forest Lands.

Landscape 285 is an area of high ruggedness with a dominant geology of sedimentary (fine grain– non calcareous) occurring in subregion NET11 – Northeast Forest Lands.

Profiles of Landscapes 519, 180, 192, 218, 138, 457, 186, 464 and 469

Landscape 519 is an area of high ruggedness with a dominant geology of sedimentary (fine grain– non calcareous) occurring in subregion NET3 – Walcha Plateau.

Landscape 180 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET11 – Northeast Forest Lands.

Landscape 192 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET11 – Northeast Forest Lands.

Landscape 218 is an area of moderate ruggedness with a dominant geology of eastern alluvials occurring in subregion NET11 – Northeast Forest Lands.

Landscape 138 is an area of high ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET12 – Tenterfield Plateau.

Landscape 457 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET19 – Round Mountain.

Landscape 186 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET11 – Northeast Forest Lands.

Landscape 464 is an area of high ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET8 – Ebor Basalts.

Landscape 469 is an area of high ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET13 – Yarrowyck – Kentucky Downs.

NEW ENGLAND TABLELAND

Landscape-scale conservation

There are 230 landscapes in the New England Tableland Bioregion (NPWS in prep). The majority of these occupy an area of less than 1% of the NSW bioregional area. Three low ruggedness landscapes (landscapes 526, 235 and 273) with varying geology and source subregions occupy between 5 and 7% of the bioregional area. One hundred and twenty-six of the 230 landscapes are represented in conservation tenures.

National parks and nature reserves

One hundred and four landscapes are represented in national parks and nature reserves. One landscape, Landscape 559, an area of low ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET3 – Walcha Plateau, has 100% of its bioregional area conserved (or 1,100 ha). Two other landscapes (560 and 465) of moderate and high ruggedness and varying geology and source subregion have between 90 and 99% of their bioregional area conserved in this system. A further 14 landscapes (475, 163, 383, 224, 285, 519, 180, 192, 218, 138, 457, 186, 464, and 469) have between 50 and 89% of their bioregional area conserved. The ruggedness of this group ranges from low to high with varying geology. Eight of the 14 have the northeast forest lands as their source subregion. Ten landscapes have between 30 and 50% and 8 landscapes have between 20 and 29% of their bioregional area conserved in national parks and nature reserves. In total, 35 of the 104 landscapes have greater than 20% of their area included under conservation tenure.

Voluntary conservation agreements

Sixteen landscapes are represented in the 7 voluntary conservation agreements in the bioregion. The area included in VCAs is generally smaller than that included in the system of national parks and nature reserves. The exceptions are Landscape 337, which is only marginally (if at all) included in national parks and nature reserves (with 0.33 ha measured), and Landscape 459, which does not appear in the latter or in any other of conservation tenure. Landscape 459 is listed as 100% cleared but Landscape 337 is about 66% cleared and has about one ha of representation in the property agreement program. The areas and proportion of landscapes included in the VCA program are listed below:

- Landscape 427 with 0.48 ha or <0.01% of its bioregional area;
- Landscape 426 with 1.25 ha or <0.01% of its bioregional area; -
- Landscape 431 with 7.24 ha or 0.11% of its bioregional area; -
- Landscape 434 with 11.73 ha or 0.14% of its bioregional area;
- Landscape 437 with 16.02 ha or 0.04% of its bioregional area; -
- Landscape 470 with 18.55 ha or 2.65% of its bioregional area; -
- Landscape 464 with 19.12 ha or 1.06% of its bioregional area;
- Landscape 465 with 20.43 ha or 2.27% of its bioregional area; -
- Landscape 459 with 24.42 ha or 2.22% of its bioregional area; -
- Landscape 355 with 24.68 ha or 0.13% of its bioregional area;
- Landscape 505 with 26.54 ha or 26.55% of its bioregional area; -
- Landscape 458 with 69.44 ha or 0.67% of its bioregional area; -
- Landscape 429 with 71.91 ha or 0.26% of its bioregional area;
- Landscape 337 with 78.99 ha or 0.46% of its bioregional area; -
- Landscape 491 with 97.41 ha or 1.87% of its bioregional area; and -
- Landscape 325 with 129.90 ha or 0.27% of its bioregional area. -

Profiles of Landscapes 427, 426, 431, 434, 437, 470, 464, 465, 459, 355, 505, 458, 429, 337, 491 and 325

Landscape 427 is an area of low ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET8 – Ebor Basalts.

Landscape 426 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET4 – Armidale Plateau.

Landscape 431 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET4 – Armidale Plateau.

Landscape 434 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET8 – Ebor Basalts.

Landscape 437 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET13 – Yarrowyck–Kentucky Downs.

Landscape 470 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET8 – Ebor Basalts.

Landscape 464 is an area of high ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET8 – Ebor Basalts.

Landscape 465 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET8 – Ebor Basalts.

Landscape 459 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET1 – Bundarra Downs.

Landscape 355 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET1 – Bundarra Downs.

Landscape 505 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion NET13 – Yarrowyck–Kentucky Downs.

Landscape 458 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET19 – Round Mountain.

Landscape 429 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET4 – Armidale Plateau.

Landscape 337 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET9 – Moredun Volcanics.

Landscape 491 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET4 – Armidale Plateau.

Landscape 325 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET9 – Moredun Volcanics.

Profiles of Landscapes 122, 47, 184, 121, 230, 234, 453, 148, 123, 299 and 437

Landscape 122 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET12 – Tenterfield Plateau.

Landscape 47 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET15 – Stanthorpe Plateau.

Landscape 184 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET14 – Binghi Plateau.

Landscape 121 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET12 – Tenterfield Plateau.

Landscape 230 is an area of low ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET11 – Northeast Forest Lands.

Landscape 234 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET11 – Northeast Forest Lands.

Landscape 453 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET4 – Armidale Plateau.

Landscape 148 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET11 – Northeast Forest Lands.

Landscape 123 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET12 – Tenterfield Plateau.

Landscape 299 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET18 – Nightcap.

Landscape 437 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET13 – Yarrowyck–Kentucky Downs.

Profiles of Landscapes 291, 150, 272, 329, 325 and 273

Landscape 291 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET18 – Nightcap.

Landscape 150 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET11 – Northeast Forest Lands.

Landscape 272 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET16 – Eastern Nandewars.

Landscape 329 is an area of low ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET9 – Moredun Volcanics.

Landscape 325 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET9 – Moredun Volcanics.

Landscape 273 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET16 – Eastern Nandewars.

Wildlife refuges

The 17 landscapes represented in the wildlife refuge program are:

- Landscape 122 with 4.28 ha or 0.01% of its bioregional area;
- Landscape 47 with 5.47 ha or 0.01% of its bioregional area;
- Landscape 184 with 7.67 ha or 0.45% of its bioregional area;
- Landscape 121 with 10.70 ha or 0.04% of its bioregional area;
- Landscape 230 with 18.12 ha or 0.15% of its bioregional area;
- Landscape 234 with 18.14 ha or 0.18% of its bioregional area;
- Landscape 453 with 25.54 ha or 0.08% of its bioregional area;
- Landscape 148 with 29.44 ha or 0.06% of its bioregional area;
- Landscape 123 with 35.64 ha or 0.28% of its bioregional area;
- Landscape 299 with 106.50 ha or 0.68% of its bioregional area;
- Landscape 437 with 139.55 ha or 0.36% of its bioregional area;
- Landscape 291 with 359.08 ha or 0.52% of its bioregional area;
- Landscape 150 with 406.05 ha or 1.09% of its bioregional area;
- Landscape 272 with 430.77 ha or 0.46% of its bioregional area;
- Landscape 329 with 736.88 ha or 3.92% of its bioregional area;
- Landscape 325 with 983.04 ha or 2.03% of its bioregional area; and
- Landscape 273 with 2920.92 ha or 1.50% of its bioregional area.

Two of these landscapes (184 and 329) are not represented in the system of national parks and nature reserves. Notably, landscape 329 is indicated to be about 81% cleared and is not represented in any of the surveyed mechanisms.

Flora reserves

Seven landscapes (probably 6 given the marginal area of landscape 349) with varying ruggedness, geology and source subregion are represented in flora reserves. These are:

- Landscape 349 with 0.0010 ha or <0.01% of its bioregional area; -
- Landscape 273 with 10.7720 ha or 0.01% of its bioregional area;
- Landscape 272 with 24.6480 ha or 0.03% of its bioregional area; -
- Landscape 521 with 65.08 ha or 0.13% of its bioregional area; -
- Landscape 525 with 82.29 ha or 0.50% of its bioregional area;
- Landscape 566 with 90.40 ha or 2.10% of its bioregional area; and -
- Landscape 524 with 567.86 ha or 0.54% of its bioregional area. -

All are also represented in national parks and nature reserves, and smaller areas are protected in flora reserves. While 2 of these landscapes, 349 and 525, achieve greater than 30% protection in national parks and nature reserves, the remainder of landscapes in the flora reserve have less than 13% of their bioregional area conserved in national park and nature reserves. The flora reserve is therefore more important in increasing the conservation status of those landscapes.

Property agreements

Twenty-seven landscapes are represented in the conservation zones of the 16 property agreements in the New England Tablelands Bioregion. Eleven of these landscapes are not represented within the bioregional system of national parks and nature reserves and many are not represented under any conservation tenure and are significantly cleared. The areas and proportions of these landscapes are identified below:

- Landscape 281 with 0.0040 ha or <0.01% of its bioregional area; and -
- Landscape 437 with 6.84 ha or 0.02% of its bioregional area. -

Those also not represented in any other of the surveyed mechanisms include:

- Landscape 455 with 2.55 ha or 0.14% of its bioregional area is about 50% cleared;
- Landscape 452 with 8.06 ha or 0.24% of its bioregional area is about 88% cleared;
- Landscape 474 with 13.75 ha or 0.18% of its bioregional area is about 97% cleared;
- Landscape 287 with 23.75 ha or 0.52% of its bioregional area is about 50% cleared;
- Landscape 430 with 30.88 ha or 0.08% of its bioregional area is about 87% cleared;
- Landscape 415 with 45.05 ha or 0.45% of its bioregional area is about 80% cleared;
- Landscape 438 with 106.27 ha or 0.29% of its bioregional area is about 84% cleared;
- Landscape 293 with 114.23 ha or 0.98% of its bioregional area is about 73 % cleared; and
- Landscape 413 with 120.88 ha or 0.56% of its bioregional area is about 81% cleared.

Aboriginal areas

About 1.87 ha of one landscape, Landscape 281, is represented in the Aboriginal area. Landscape 281 is an area of low ruggedness with a dominant geology of acid igneous intrusives is sourced from the Tingha Plateau subregion. Although the area of the Landscape included in the Aboriginal area is small, this landscape is not represented in any of the other surveyed mechanisms, including the system of national parks and nature reserves.

Profiles of landscapes 349, 273, 272, 521, 525, 566 and 524

Landscape 349 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET5 – Wongwibinda Plateau.

Landscape 273 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET16 – Eastern Nandewars.

Landscape 272 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET16 – Eastern Nandewars.

Landscape 521 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET3 – Walcha Plateau.

Landscape 525 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET3 – Walcha Plateau.

Landscape 566 is an area of high ruggedness with a dominant geology of basic/intermediate igneous and associated sediments and metasediments occurring in subregion NET3 – Walcha Plateau.

Landscape 524 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET3 – Walcha Plateau.

Profiles of Landscapes 209, 183, 197, 221, 201, 208, 213, 184, 157, 159 and 156

Landscape 209 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NET6 – Deepwater Downs.

Landscape 183 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET2 – Beardy River Hills.

Landscape 197 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET2 – Beardy River Hills.

Landscape 221 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET2 – Beardy River Hills.

Landscape 201 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET6 – Deepwater Downs.

Landscape 208 is an area of moderate ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NET6 – Deepwater Downs.

Landscape 213 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) and associated sediments occurring in subregion NET6 – Deepwater Downs.

Landscape 184 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET14 – Binghi Plateau.

Landscape 157 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NET14 – Binghi Plateau.

Landscape 159 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET14 – Binghi Plateau.

Landscape 156 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NET14 – Binghi Plateau.

State recreation areas

Eleven landscapes are represented in state recreation areas. Only 2 of these (Landscape 201, about 3 ha, and Landscape 213, with less than 1 ha), are also represented in the system of national parks and nature reserves and their area is so small as to be insignificant or inaccurate. Note the significant proportion of landscapes 159 and 156 included in the state recreation area. Both fall on the same geology in the Binghi Plateau subregion but have different ruggedness. Landscapes included in SRAs are outlined below:

- Landscape 209 with 1.19 ha or 0.04% of its bioregional area;
- Landscape 183 with 1.77 ha or 0.02% of its bioregional area; -
- Landscape 197 with 44.59 ha or 0.48% of its bioregional area; -
- Landscape 221 with 60.43 ha or 4.32% of its bioregional area;
- Landscape 201 with 63.38 ha or 0.20% of its bioregional area; -
- Landscape 208 with 83.35 ha or 41.68% of its bioregional area; -
- Landscape 213 with 143.24 ha or 2.60% of its bioregional area;
- Landscape 184 with 166.07 ha or 9.77% of its bioregional area; -
- Landscape 157 with 179.91 ha or 14.99% of its bioregional area; -
- Landscape 159 with 5767.46 ha or 39.78% of its bioregional area; and
- Landscape 156 with 22957.92 ha or 50.90% of its bioregional area; -

Crown reserves

Three low to moderate ruggedness landscapes with igneous geology and sourced in the Tenterfield subregion are represented in areas of Crown reserve managed by NPWS. Although all 3 are represented in national parks and nature reserves, the proportion of the last (while larger than its proportion in Crown reserve) is still relatively small.

- Landscape 122 with 4.79 ha or 0.01% of its bioregional area; -
- Landscape 121 with 6.70 ha or 0.02% of its bioregional area; and -
- Landscape 123 with 207.95 ha or 1.64% of its bioregional area. -

Conservation and clearing

A considerable proportion, 1,656,100 ha or 57.95%, of the New England Tableland Bioregion has been cleared of its native canopy vegetation, making it the fourth highest cleared of NSW bioregions and clearing is spread across the majority (198) of the 230 landscapes.

Only 77 of the landscapes are less than 30% cleared (32 with 0% indicated). Seventy-three landscapes have greater than 70% of their area cleared, and 23 of these are 100% cleared. Only 19 of these are represented in national parks and nature reserves. Those landscapes having low representation in the more secure forms of conservation management (national parks and nature reserves, flora reserves, voluntary conservation agreements and property agreements, if perpetual) and particularly those which are highly cleared, are priorities for conservation or restoration.

NORTH COAST

Landscape-scale conservation

The North Coast Bioregion is covered by 136 landscapes (NPWS in prep). While the majority of the landscapes occupy less than 1% of the bioregion, the dominant landscape is Landscape 388, occupying 934,300 ha or 16.45% of the bioregion.

National parks and nature reserves

Of the 136 landscapes in the North Coast Bioregion 107 are included in the system of national parks and nature reserves. Forty-five landscapes have greater than 20% of their bioregional area in the reserve system. No landscapes across the full range of ruggedness and with varying geology have 100% of their area included. One landscape (Landscape 22) has between 90 and 99% of its area included in national parks and nature reserves and 19 landscapes have between 50 and 89% of their bioregional area in the reserve system (one between 80 and 89%, 4 between 70 and 79%, 4 between 60 and 69% and 10 between 50 and 59%). Landscape 388, the largest landscape by area within the bioregion, also occupies the largest area of a landscape conserved in national parks and nature reserves.

Historic sites

Three low ruggedness landscapes are represented in historic sites in the bioregion. As is usually the case, historic sites involve only small areas and percentages of landscapes. Each of these landscapes is also represented to a greater or lesser degree within the reserve system. These landscapes are:

- Landscape 226 with 326.42 ha or 0.14% of its bioregional area; -
- Landscape 270 with 147.96 ha or 0.18% of its bioregional area; and
- Landscape 2 with 8.42 ha or 0.65% of its bioregional area. -

Aboriginal areas

Four landscapes with varying ruggedness and geology are represented in Aboriginal areas. A greater area of these are also represented in the reserve system. The areas and proportion of each of these landscapes is listed below:

- Landscape 473 with 113.45 ha or 0.06% of its bioregional area; -
- Landscape 440 with 9.76 ha or 0.03% of its bioregional area; -
- Landscape 497 with 2.11 ha or 0.01% of its bioregional area; and
- Landscape 92 with 0.30 ha or <0.01% of its bioregional area. -

State recreation areas

Five of the North Coast landscapes are represented in state recreation areas. All of these landscapes are also represented to varying degrees in national parks and nature reserves. The areas and proportion of these landscapes in state recreation areas is listed below:

- Landscape 380 with 65.43 ha or 0.16 % of its bioregional area;
- Landscape 428 with 28.45 ha or 0.02% of its bioregional area; -
- Landscape 388 with 26.43 ha or <0.01% of its bioregional area; -
- Landscape 270 with 9.04 ha or 0.01% of its bioregional area; and
- Landscape 13 with 6.50 ha or 0.06% of its bioregional area. -

Landscape 388 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NNC2 – Manning – Macleay.

Profiles of Landscapes 266, 270 and 2

Landscape 266 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion NNC2 – Manning – Macleay.

Landscape 270 is an area of low ruggedness with a dominant geology of coastal sands occurring in subregion NNC2 – Manning – Macleay.

Landscape 2 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEQ4 – Southern Coastal Lowlands.

Profiles of Landscapes 473, 440, 497 and 92

Landscape 473 is an area of moderate ruggedness with a dominant geology of acid metamorphics occurring in subregion NNC2 – Manning – Macleay.

Landscape 440 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NNC2 – Manning – Macleay.

Landscape 497 is an area of low ruggedness with a dominant geology of acid metamorphics occurring in subregion NNC2 – Manning – Macleay.

Landscape 92 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SEQ12 – Clarence Basin.

Profiles of Landscapes 380, 428, 13, 78 and 98

Landscape 380 is an area of low ruggedness with a dominant geology of basic/intermediate igneous and associated sediments & metasediments occurring in subregion NNC2 – Manning – Macleay.

Landscape 428 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous and associated sediments & metasediments occurring in subregion NNC2 – Manning – Macleay.

Landscape 13 is an area of low ruggedness with a dominant geology of coastal sands occurring in subregion SEQ3 – Murwillumbah (Qld – Southeast Hills and Ranges).

Landscape 78 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEQ12 – Clarence Basin.

Landscape 98 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SEQ12 – Clarence Basin.

Profiles of Landscapes 79, 77, 440, 76, 446, 322, 421, 460, 494, 462 and 90

Landscape 79 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEQ12 – Clarence Basin.

Landscape 77 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SEQ12 – Clarence Basin.

Landscape 440 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NNC2 – Manning – Macleay.

Landscape 76 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEQ12 – Clarence Basin.

Landscape 446 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NNC2 – Manning – Macleay.

Landscape 322 is an area of moderate ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion NNC2 – Manning – Macleay.

Landscape 421 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NNC2 – Manning – Macleay.

Landscape 460 is an area of high ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NNC2 – Manning – Macleay.

Landscape 494 is an area of high ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion NNC2 – Manning – Macleay.

Landscape 462 is an area of high ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion NNC2 – Manning – Macleay.

Landscape 90 is an area of moderate ruggedness with a dominant geology of eastern alluvials occurring in subregion SEQ12 – Clarence Basin.

Profiles of Landscapes 16 and 1

Landscape 16 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SEQ10 – Richmond – Tweed (Qld – Scenic Rim).

Landscape 1 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEQ3 – Murwillumbah (Qld – Southeast Hills and Ranges).

Profiles of Landscapes 23, 4, 594, 557 and 79

Landscape 23 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEQ10 – Richmond – Tweed (Qld – Scenic Rim).

Landscape 4 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEQ3 – Murwillumbah (Qld – Southeast Hills and Ranges).

Landscape 594 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB2 – Hunter.

Landscape 557 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion NNC2 – Manning – Macleay.

Landscape 79 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEQ12 – Clarence Basin.

Crown reserves

The areas of Crown reserves managed by the NPWS in the North Coast Bioregion encompasses 16 landscapes of varying ruggedness and geology. All are also represented to varying degrees in the system of national parks and nature reserves.

- Landscape 78 with 5183.53 ha or 1.79% of its bioregional area;
- Landscape 428 with 3353.34 ha or 1.97% of its bioregional area; -
- Landscape 98 with 2957.45 ha or 1.44% of its bioregional area; -
- Landscape 380 with 2430.59 ha or 5.97% of its bioregional area;
- Landscape 79 with 2376.32 ha or 0.90% of its bioregional area; -
- Landscape 77 with 2277.11 ha or 2.54% of its bioregional area; -
- Landscape 440 with 1396.09 ha or 3.76% of its bioregional area;
- Landscape 76 with 565.68 ha or 0.90% of its bioregional area; -
- Landscape 388 with 469.44 ha or 0.05% of its bioregional area; -
- Landscape 446 with 300.00 ha or 2.01% of its bioregional area;
- Landscape 322 with 211.92 ha or 0.15% of its bioregional area; -
- Landscape 421 with 133.75 ha or 0.09% of its bioregional area; -
- Landscape 460 with 107.11 ha or 1.01% of its bioregional area;
- Landscape 494 with 55.73 ha or 0.14% of its bioregional area; -
- Landscape 462 with 36.20 ha or 0.10% of its bioregional area; and -
- Landscape 90 with 8.08 ha or 0.15 % of its bioregional area. -

Flora reserves

Twenty-three landscapes are represented in flora reserves (388, 322, 494, 271, 64, 78, 62, 76, 462, 58, 421, 473, 79, 61, 98, 68, 77, 11, 440, 268, 594, 266 and 10). They have a variety of ruggedness (low to high), varying geology and are sourced from several subregions. All are also represented in the reserve system. Flora reserves contribute to the conservation of less that 2.1% of the bioregional area of each landscape in all 23 cases.

Voluntary conservation agreements

VCAs on land in the North Coast Bioregion cross 25 landscapes. The majority of these landscapes are low ruggedness with varying geology and the source subregions. As with VCAs generally, the areas conserved are relatively small. Eight of these have lower than 5% representation in this system and are listed below:

- Landscape 497 with 0.03 ha or <0.01% of its bioregional area; -
- Landscape 16 with 0.37 ha or <0.01% of its bioregional area;
- Landscape 1 with 1.55 ha or 0.01% of its bioregional area; -
- Landscape 23 with 2.06 ha or 0.01% of its bioregional area; -
- Landscape 4 with 26.73 ha or 0.11% of its bioregional area;
- Landscape 594 with 26.89 ha or 0.07% of its bioregional area; -
- Landscape 557 with 32.43 ha or 0.04% of its bioregional area; and -
- Landscape 79 with 39.60 ha or 0.02% of its bioregional area. -

Wildlife refuges

Sixty-three landscapes are represented in the wildlife refuge program. This makes it the largest contributor (albeit a less certain contribution both in terms of security and degree of active management) to inclusion of the range of landscapes in conservation mechanisms outside of the reserve system. Five of these are not represented at all in national parks and nature reserves. (Their area and proportional representation in wildlife refuges are listed below and a description of these landscapes is included in the text box) while 39 others have less than 20% of their bioregional area in this system of reserves. Landscapes not also represented in national parks and nature reserves include:

- Landscape 125 with 0.01 ha or <0.01% of its bioregional area;
- Landscape 45 with 87.97 ha or 8.00% of its bioregional area; -
- Landscape 66 with 165.94 ha or 6.64% of its bioregional area; -
- Landscape 59 with 195.40 ha or 6.30% of its bioregional area;
- Landscape 161 with 1321.36 ha or 38.86% of its bioregional area; and -
- Landscape 160 with 1923.98 ha or 35.08% of its bioregional area. -

Property agreements

Thirty-nine landscapes have been included win property agreements. One landscape (Landscape 27 with 30.97 ha or 1.07% of its bioregional area) is not represented in any of the other conservation mechanisms. A small area (3.31 ha or 0.11% of its bioregional area) of one landscape (59) which is also represented in the wildlife refuge program, does not also occur in the reserve system. Twelve others have less than 5% representation in the reserve system; their areas, proportions and descriptions are included below and in the text boxes.

- Landscape 661 with 0.55 ha or 0.01% of its bioregional area; -
- Landscape 620 with 1.19 ha or 0.01% of its bioregional area; -
- Landscape 24 with 1.71 ha or 0.05% of its bioregional area;
- Landscape 380 with 3.71 ha or 0.01% of its bioregional area; -
- Landscape 93 with 6.54 ha or 0.23% of its bioregional area; -
- Landscape 79 with 7.30 ha or <0.01% of its bioregional area;
- Landscape 557 with 8.51 ha or 0.01% of its bioregional area; -
- Landscape 23 with 12.96 ha or 0.04% f its bioregional area; -
- Landscape 497 with 19.45 ha or 0.05% of its bioregional area;
- Landscape 65 with 44.36 ha or 0.09% of its bioregional area; -
- Landscape 26 with 66.45 ha or 0.18% of its bioregional area; and -
- Landscape 16 with 131.47 ha or 0.11% of its bioregional area. -

Conservation and clearing

Almost one third, 2,184,000 ha or 38.46% of the North Coast Bioregion has been cleared of native canopy vegetation. More than half (75) of the 136 landscapes are more than 30% cleared (4 are 100% cleared, 23 in the 70-99% range of clearing, 28 in the 50-70% clearing range and 20 between 30 and 49% cleared).

Twenty-three of the landscapes in the North Coast Bioregion are not in any of the mechanisms surveyed. Those landscapes having low representation in the more secure forms of conservation management (national parks/nature reserves, flora reserves, voluntary conservation agreement and property agreement (if perpetual) and particularly those which are highly cleared) are priorities for conservation or restoration.

Profiles of Landscapes 125, 45, 66, 59, 161, and 160

Landscape 125 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEQ12 – Clarence Basin.

Landscape 45 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEQ10 – Richmond – Tweed (Qld – Scenic Rim).

Landscape 66 is an area of moderate ruggedness with a dominant geology of eastern alluvials occurring in subregion NNC1 – Nymboida.

Landscape 59 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NNC1 – Nymboida.

Landscape 161 is an area of moderate ruggedness with a dominant geology of ultra basic igneous intrusives occurring in subregion NNC1 – Nymboida.

Landscape 160 is an area of low ruggedness with a dominant geology of ultra basic igneous intrusives occurring in subregion NNC1 – Nymboida.

Profiles of Landscapes 661, 620, 24, 93, 65 and 26

Landscape 661 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB2 – Hunter.

Landscape 620 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SB2 – Hunter.

Landscape 24 is an area of moderate ruggedness with a dominant geology of eastern alluvials occurring in subregion SEQ10 – Richmond – Tweed (Qld – Scenic Rim).

Landscape 93 is an area of low ruggedness with a dominant geology of coastal sands occurring in subregion SEQ10 – Richmond – Tweed (Qld – Scenic Rim).

Landscape 65 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion NNC1 – Nymboida.

Landscape 26 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEQ11 – Woodenbong.

Landscape 659 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NSS2 – Lower Slopes.

Profiles of Landscapes 672, 659, 637, 610, 686, 628, 614, 635, 684, 668 and 629

Landscape 672 is an area of low ruggedness with a dominant geology of sedimentary (calcareous) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 659 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NSS2 – Lower Slopes.

Landscape 637 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 610 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 686 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 628 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 614 is an area of low ruggedness with a dominant geology of western alluvials (inactive) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 635 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 684 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NSS2 – Lower Slopes.

Landscape 668 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NSS2 – Lower Slopes.

Landscape 629 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Profiles of Landscapes 980, 680, 679, 721, 725, 613 and 695

Landscape 980 is an area of low ruggedness with a dominant geology of ultra basic igneous intrusives occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 680 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 679 is an area of low ruggedness with a dominant geology of inland plain sediments occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 721 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion NSS2 – Lower Slopes.

Landscape 725 is an area of high ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 613 is an area of low ruggedness with a dominant geology of acid metamorphics occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 695 is an area of moderate ruggedness with a dominant geology of sedimentary (calcareous) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

SOUTH WESTERN SLOPES

Landscape-scale conservation

There are 109 landscapes in the South Western Slopes, the majority of which are of low to moderate ruggedness (NPWS in prep).

The alluvial, low ruggedness and highly cleared landscape, Landscape 659, dominates the bioregion, occupying 2,170,400.00 ha or 26.90% of the bioregional area. The majority of the remaining landscapes (93) occupy less than one per cent of the bioregional area.

National parks and nature reserves

Forty-four of the 109 landscapes are represented in the bioregional system of national parks and nature reserves. The range of landscapes included in this system is larger than that encompassed by any of the other conservation tenures. Eleven landscapes have greater than 20% of their bioregional area preserved, with 6 of this group having greater than 30% and 3 having greater than 70%. In terms of area protected, the largest area protected is 14,637.53 ha (or 7.30% of its bioregional area) of Landscape 640. This landscape is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes. In terms of proportion conserved, the small Landscape 1053 (of less than or equal to 100 ha) is 100% reserved. Only 57.74 ha (<0.01%) of the dominant landscape is represented in the reserve system and this is the second smallest area reserved (of those landscapes reserved).

Voluntary conservation agreements

Eleven landscapes are represented in VCAs in the bioregion. Only one of these, Landscape 672, is not included in national parks and nature reserves. Although this landscape is only very marginally represented (.25 ha) in the VCA program, it is significantly cleared (97.72%). The area and percentage area of landscapes in VCAs is detailed below:

- Landscape 672 with 0.25 ha or <0.01% of its bioregional area;
- Landscape 659 with 2.43 ha or <0.01% of its bioregional area; -
- Landscape 637 with 2.56 ha or <0.01% of its bioregional area; -
- Landscape 610 with 3.64 ha or <0.01% of its bioregional area;
- Landscape 686 with 12.11 ha or 0.01% of its bioregional area; -
- Landscape 628 with 33.86 ha or 0.10% of its bioregional area; -
- Landscape 614 with 103.48 ha or 0.02% of its bioregional area;
- Landscape 635 with 104.45 ha or 0.02% of its bioregional area; -
- Landscape 684 with 192.80 ha or 0.18% of its bioregional area; -
- Landscape 668 with 206.90 ha or 0.02% of its bioregional area; and
- Landscape 629 with 221.65 ha or 0.38% of its bioregional area. -

Wildlife refuges

Thirty-three landscapes are represented in the wildlife refuge program. Eight of these are not included in national parks or nature reserves. The areas and proportions of these 8 landscapes are listed below:

- Landscape 679 with 13.24 ha or 0.09% of its bioregional area; -
- Landscape 721 with 71.24 ha or 0.17% of its bioregional area;
- Landscape 680 with 0.96 ha or 0.32% of its bioregional area; -
- Landscape 613 with 172.28 ha or 0.72% of its bioregional area; -
- Landscape 672 with 569.87 ha or 1.45% of its bioregional area;
- Landscape 695 with 212.96 ha or 4.53% of its bioregional area; -
- Landscape 980 with 491.49 ha or 7.12% of its bioregional area; and -
- Landscape 725 with 115.85 ha or 11.59% of its bioregional area. -

Flora reserve

Thirteen landscapes are represented in flora reserves in the bioregion. Six of these (1066, 1050, 1061, 1042, 1083 and 1074) are not represented in national parks and nature reserves. Significantly, Landscape 1083 has more than 30% of its area included in flora reserves. Landscape 659 does receive some additional representation in flora reserves but its level of conservation is relatively small given its bioregional area. The areas and proportions of landscapes included are:

- Landscape 1066 with 0.65 ha or 0.01% of its bioregional area;
- Landscape 1050 with 27.39 ha or 0.36% of its bioregional area; -
- Landscape 1061 with 30.27 ha or 3.78% of its bioregional area; -
- Landscape 659 with 72.11 ha or <0.01% of its bioregional area;
- Landscape 610 with 77.65 ha or 0.01% of its bioregional area; -
- Landscape 674 with 147.48 ha or 0.13% of its bioregional area; -
- Landscape 640 with 215.65 ha or 0.11% of its bioregional area;
- Landscape 668 with 228.61 ha or 0.03% of its bioregional area; -
- Landscape 1042 with 248.35 ha or 22.58% of its bioregional area; -
- Landscape 1040 with 538.38 ha or 8.55% of is bioregional area;
- Landscape 1083 with 763.20 ha or 38.16% of its bioregional area; -
- Landscape 1074 with 851.43 ha or 19.35% of its bioregional area; and -
- Landscape 609 with 1756.98 ha or 0.30% of its bioregional area. -

Of those landscapes also represented within the reserve program it is worth noting that 19,958.69 ha (or .92% of its bioregional area) of Landscape 659 (the dominant landscape in the bioregion) receives greater representation in the wildlife refuges in the bioregion than from any other of the conservation mechanisms surveyed.

Property agreements

Thirty landscapes are represented in property agreements in the South Western Slopes. Of these landscapes, 4 are not also represented in national parks and nature reserves. The area and proportion of these landscapes are listed below:

- Landscape 672 with 10.05 ha or 0.03% of its bioregional area;
- Landscape 676 with 13.73 ha or 0.03% of its bioregional area; -
- Landscape 721 with 18.68 ha or 0.05% of its bioregional area; and -
- Landscape 956 with 31.83 ha or 0.30% of its bioregional area. -

Conservation and clearing

The South Western Slopes is a highly cleared bioregion. More than 6 million ha or 85.08% of the bioregion has been cleared. At the landscape scale, 71 landscapes are more than 70% cleared (20 are 100%, 15 between 90 and 99%, 26 between 80 and 89% and 10 are between 70 and 79% cleared). Many of those landscapes which are 100% cleared are in fact relatively small landscapes, but the areas cleared for landscapes in the groups between 90 and 70% are often substantial. Only 10 landscapes are indicated as being intact and these are nearly all smaller than or equal to 100 ha. The most cleared landscape in terms of area cleared is the dominant landscape, Landscape 659, with 1,951,400 ha or 89.91% of its area cleared.

Not surprisingly, conservation of landscapes in the bioregion is not comprehensive, with just over half (61) of the 109 landscapes in the bioregion having some representation in conservation tenures.

Profiles of Landscapes 1066, 1050, 1061, 674, 640, 1042, 1040, 1083, 1074 and 609

Landscape 1066 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH14 – Bondo.

Landscape 1050 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH14 – Bondo.

Landscape 1061 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SEH14 – Bondo.

Landscape 674 is an area of low ruggedness with a dominant geology of western floodplains (active) occurring in subregion NSS2 – Lower Slopes.

Landscape 640 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 1042 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH14 – Bondo.

Landscape 1040 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH14 – Bondo.

Landscape 1083 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEH14 – Bondo

Landscape 1074 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEH14 – Bondo

Landscape 609 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Profiles of Landscapes 676 and 956

Landscape 676 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion NSS2 – Lower Slopes.

Landscape 956 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEH6 – Murrumbateman.

RIVERINA

Landscape-scale conservation

The Riverina Bioregion is composed of 40 landscapes (Mitchell in prep), 3 of which, the Oaklands Hills and Footslopes (occupying 9,234.25 ha or 0.13% of the bioregion), the Riverina Dunefields (occupying 9.83 ha or 0.00014% of the bioregion) and the very small Riverina Sandplains (occupying 0.83 ha or 0.00001% of the bioregion), are endemic to the bioregion.

The size of landscapes in the bioregion ranges from the endemic Riverina Sandplains landscape to the Murrumbidgee Scalded Plains landscape, which occupies the largest area at almost 15.54% (1,100,612 ha) of the bioregion. However, over 88% of the bioregion is dominated by just 8 of the 40 landscapes, with the majority of the remainder each occupying less than 1% of the bioregion. The 8 dominant landscapes are the:

- Murrumbidgee Depression Plains occupying 624,851.61 ha or 8.83% of the bioregional area;
- Lachlan Depression Plains occupying 649,270.31 ha or 9.17% of the bioregional area;
- Lachlan Channels and Floodplains occupying 666,183.82 ha or 9.41% of the bioregional area;
- Murray Scalded Plains occupying 710,927.06 ha or 10.04% of the bioregional area;
- Murray Channels and Floodplains occupying 758,375.83 ha or 10.71% of the bioregional area;
- Murrumbidgee Channels and floodplains occupying 863,306.64 ha or 12.19% of the bioregional area;
- Lachlan Scalded Plains occupying 883,331.56 ha or 12.48% of the bioregional area; and
- Murrumbidgee Scalded Plains occupying 1,100,612.30 ha or 15.54% of the bioregional area.

Landscapes in the bioregion are not comprehensively reserved or managed under conservation-oriented management regimes. Nine of the 40 landscapes are represented in reserves but only a small percentage of each is included. Less than half (18) of the landscapes are protected within the conservation mechanisms surveyed. The greatest proportion of any landscape represented in conservation tenures is 5.2% of the Murrumbidgee Scalded Plain landscape (which occurs within reserves, the historic site, the voluntary conservation agreement, wildlife refuges and property agreements).

National parks and nature reserves

As already noted, 9 of the 40 landscapes are represented in national parks and nature reserves. The Lachlan Depression Plains landscape has the greatest area and proportion of the bioregional area of its landscape reserved, with almost 14,366.95 ha or 2.21% of its bioregional area reserved. Five of the 8 dominant landscapes have some representation, but none of the landscapes endemic to the bioregion is represented within reserves.

Historic sites

One landscape, the Murrumbidgee Scalded Plains, is represented in the historic site, with just 21.48 ha and 0.002% of its area included. About 0.01% of this landscape also occurs in national parks and nature reserves.

Voluntary conservation agreement

The only landscape represented in the one voluntary conservation agreement in the bioregion is the Murrumbidgee Scalded Plains landscape at 17.90 ha.

Wildlife refuges

Thirteen landscapes occur in wildlife refuges in the bioregion, 8 of which are not included in national parks and nature reserves. They are:

- Murrumbidgee Source-bordering Dunes landscape with 1035.77 ha or 3.62% of its bioregional area;
- Murrumbidgee Channels and Floodplains landscape with 1,1016.90 ha or 1.28% of its bioregional area;
- Murrumbidgee Depression Plains landscape 5811.85 ha or 0.93% of its bioregional area;
- Murray Depression Plains landscape 680.75 ha or 0.55% of its bioregional area;
- Albury-Oaklands Hills and Footslopes landscape 67.27 ha or 0.40% of its bioregional area;
- Murray Scalded Plains landscape with 638.93 ha or 0.09% of its bioregional area;
- Mallee Cliffs Sandplains landscape with 24.79 ha or 0.04% of its bioregional area; and
- Murray Source-bordering Dunes landscape with 4.31 ha or 0.01% of its bioregional area.

One of these landscapes, the Albury Oaklands Hills and Footslopes landscape (which is 97.26% cleared), is not included in any other conservation tenure and has only a small representation of 67.27 ha or 0.40% of its bioregional area included in a wildlife refuge.

Flora reserve

Five landscapes are represented in the 9 flora reserves in the bioregion. These are also all represented in other conservation tenures although 4 are not represented in national parks and nature reserves. These are:

- Murrumbidgee Source-bordering Dunes landscape with 0.02 ha or <0.01% of its bioregional area;
- Murray Scalded Plains landscape with 0.70 ha or <0.01% of its bioregional area;
- Murray Source-bordering Dunes landscape with 11.28 ha or 0.03% of its bioregional area; and
- Murray Lakes, Swamps and Lunettes landscape with 924.05 ha or 1.42% of its bioregional area.

Property agreements

Ten landscapes are represented in property agreements in the bioregion. Eight are not represented in national parks or nature reserves. These are:

- Murrumbidgee Depression Plains landscape with 30.13 ha or <0.01% of its bioregional area;
- Murrumbidgee Channels and Floodplain landscape with 63.57 ha or 0.01% of its bioregional area;
- Murray Scalded Plains landscape with 221.24 ha or 0.03% of its bioregional area;
- Murray Lakes, Swamps and Lunettes landscape with 37.48 ha or 0.06% of its bioregional area;
- Murray Depression Plains landscape with 132.19 ha or 0.11% of its bioregional area;
- Billabong Creek Alluvial Plains landscape with 27.57 ha or 0.36% of its bioregional area;
- Oaklands Hills and Footslopes landscape with 37.13 ha or 0.40% of its bioregional area. Importantly, this is endemic to the bioregion; and
- Murray Source-bordering Dunes landscape with 176.04 ha or 0.47% of its bioregional area.

Two landscapes (Oaklands Hills and Footslopes, 95.30% cleared, Billabong Creek Alluvial Plain, 95.18% cleared) not represented in other conservation tenures occur in property agreements.

Conservation and clearing

About 1,994,194 ha or 28.17% of the Riverina Bioregion has been cleared of its native canopy vegetation. Three-quarters of the landscapes have experienced this type of clearing with just under half of the landscapes having more than 30% of their bioregional area cleared. The relatively small (94 ha) Cocoparra Basalt Hills landscape has been totally cleared. A further 9 landscapes are extremely cleared, with between 70 and 100% of their bioregional area cleared. They are the Murray Source-bordering Dunes, Murrumbidgee Sandplains, Murray Sandplains, Cocoparra Ranges and Footslopes, Murray Depression Plains, Murray Scalded Plains, Billabong Creek Alluvial Plain, Oaklands Hills and Footslopes and Albury-Oaklands Hills and Footslopes. Four landscapes are highly cleared with between 50 and 70% of their bioregional area cleared. These are the Murray Lakes, Swamps and Lunettes, Mallee Cliffs Linear Dunes, Buckingong Gravels and the Mallee Cliffs Sandplains landscapes. Four landscapes have more than 30% of their area cleared. They are the Murrumbidgee Source-bordering Dunes, the Murrumbidgee Lakes, Swamps and Lunettes, the Ivanhoe-Nangara Sandplains and the Murray Channels and Floodplains landscapes.

Many of the highly to extremely cleared landscapes have some representation in conservation tenures in the bioregion. Four (Murrumbidgee Lakes, Swamps and Lunettes, Ivanhoe-Nangara Sandplains, Murray Channels and Floodplains and Buckingong Gravels) are represented in national parks and nature reserves. Three (the Murray Channels and Floodplains, Murray Lakes, Swamps and Lunettes and Murray Source-bordering Dunes landscapes) are represented in flora reserves. The wildlife refuge program includes the largest range (7) of these landscapes (Murrumbidgee Source-bordering Dunes, Murrumbidgee Lakes, Swamps and Lunettes, Ivanhoe-Nangara Sandplains, Murray Channels and Floodplains, Mallee Cliffs Sandplains, Murray Depression Plains, and Albury-Oaklands Hills and Footslopes). Four of the high to extremely cleared landscapes (Murray Source-bordering Dunes, Murray Depression Plains, Murray Scalded Plains, Billabong Creek Alluvial Plain and Oaklands Hills and Footslopes) are represented in the conservation zone of property agreements.

SIMPSON STRZELECKI DUNEFIELDS

Landscape-scale conservation

Thirty-three landscapes occur in the bioregion, and 2 of these, the Bulloo Sandplains and Tibooburra Salt Lakes and Playas, are endemic to the bioregion (Mitchell in prep).

Most landscapes individually occupy less than 5% of the bioregion. The smallest, the Mootwingee-Wonnaminta Ranges landscape, occupies 5.90 ha or 0.0003% of the bioregion. However, the largest landscape, the Sturt Linear Dunes, occupies almost half (41.81% and about 883,873 ha) of the bioregion, while Bulloo Linear Dunes (12.21%) and Ursino Linear Dunes (9.65%) are also significant. Other landscapes that individually occupy more than 2% of the bioregion are: Tibooburra Alluvial Plains (4.69%), Mootwingee-Wonnaminta Alluvial Plains (3.78%), Bulloo Salt Lakes and Playas (3.01%), Ursino Alluvial Plains (2.89%), Barrier Sandplains (2.56%), Barrier Alluvial Plains (2.32%), Mootwingee-Wonnaminta Sandplains (2.31%) and Tibooburra Sandplains (2.27%).

At the landscape scale, this bioregion is not comprehensively conserved. Of the 33 landscapes occurring in the bioregion, only 17 are represented in any of the conservation tenures and only 7 are reserved. Both endemic landscapes have some representation in conservation tenures although only one is reserved.

The most noticeable form of clearing measured in this report, namely that of native canopy, is indicated to be intact for this bioregion for all landscapes.

National parks and nature reserves

Seven landscapes occur in Sturt National Park. Of these, 2 (Tibooburra Fresh Lakes and Swamps at 6,817.75 ha or 27.91% and Tibooburra Downs 9,280.79 ha or at 24.09%), have more than 20% of their bioregional area represented in the national park. Two more landscapes (Tibooburra Salt Lakes and Playas at 2,897.39 ha or 18.71% of its bioregional area and Sturt Linear Dunes at 91,866.67 ha or 10.39% of its bioregional area) have more than 10% of their area reserved. Of note, the Tibooburra Salt Lakes and Playas landscape can be considered endemic to the NSW portion of this bioregion.

Aboriginal area

Three landscapes are represented in the Aboriginal area:

- Bulloo Channels and Floodouts 530.75 ha or 0.03% of its bioregional area;
- Bulloo Littoral and Lunettes 34787.27 ha or 1.65% of its bioregional area; and
- Tibooburra Tablelands 25687.41 ha or 1.22% of its bioregional area.

Only one landscape, the Tibooburra Tablelands landscape, is also represented in national parks and nature reserves.

Wildlife refuges

Fourteen landscapes occur in wildlife refuges and for some this is a significant proportion of their bioregional area. These are Bulloo Channels and Floodouts (52.14%), Bulloo Sandplains (46.51%), White Cliffs Alluvial Plains (28.20%), Tibooburra Sandplains (22.63%), Bulloo Linear Dunes (21.96%) and Ursino Sandplains (18.26%). Nine of the 14 landscapes represented in wildlife refuges do not occur in the Sturt National Park. These are:

- Ursino Alluvial Plains with 226.37 ha or 0.37% of its bioregional area;
- Bulloo Channels and Floodouts with 276.72 ha or 52.14% of its bioregional area;
- Ursino Tablelands and Downs with 1,039.26 ha or 9.41% of its bioregional area;
- Bulloo Littoral and Lunettes with 2,410.12 ha or 6.93% of its bioregional area;
- Ursino Sandplains with 4,841.73 ha or 18.26% of its bioregional area;
- Ursino Linear Dunes with 6,115.18 ha or 3.00% of its bioregional area;
- White Cliffs Alluvial Plains with 7,402.77 ha or 28.20% of its bioregional area;
- Bulloo Salt Lakes and Playas with 9,215.88 ha or 14.47% of its bioregional area;
- Bulloo Sandplains with 10,029.26 ha or 46.51% of its bioregional area and
- Bulloo Linear Dunes with 56,677.99 ha or 21.96% of its bioregional area.

SOUTH EAST CORNER

Landscape-scale conservation

The South East Corner Bioregion is composed of 69 landscapes (NPWS in prep). Three landscapes (1094 with an area of 280500.00 ha or 21.64% of the bioregion, 1097 with an area of 155,100.00 ha and occupying 11.96% of the bioregion and 1129 with 197,300.00 ha or 15.22% of the bioregion) occupy almost half of the bioregional area. The majority of the remaining landscapes occupy less than 1% of the bioregional area. Three of the 69 landscapes (1015, 1136, and 1161) are not represented in any of the conservation tenures, and 66.67% of the area of Landscape 1015 is cleared.

National parks and nature reserves

Sixty-four of the 69 landscapes are represented in national parks and nature reserves. Twelve landscapes (948, 949, 1012, 1016, 1017, 1064,1090, 1092, 1096, 1112, 1143,1 145), some of which are relatively small, have 100% of their area represented and in fact only 20 of these have less than 20% of their bioregional area represented in the bioregion.

Historic site

The Davidson Whaling Station historic site incorporates more (15.98 ha) of Landscape 1097, which already has approximately 29% of its area represented in the reserve system. Of course the intention of the historic site is to conserve the historic heritage.

Voluntary conservation agreements

Seven landscapes are represented in voluntary conservation agreements:

- Landscape 1134 with 2.68 ha or 0.02% of its bioregional area;
- Landscape 1132 with 20.99 ha or 0.07% of its bioregional area;
- Landscape 1095 with 21.16 ha or 0.04% of its bioregional area;
- Landscape 1097 with 27.35 ha or 0.02% of its bioregional area;
- Landscape 1133 with 29.79 ha or 0.03% of its bioregional area;
- Landscape 1094 with 45.40 ha or 0.02% of its bioregional area; and
- Landscape 1129 with 563.72 ha or 0.29% of its bioregional area.

These have a variety of geology and ruggedness but all originate in the South East Coastal Ranges subregion. They are all represented in the reserves system.

Profiles of Landscapes 1094, 1097, 1129, 1015, 1136 and 1161

Landscape 1094 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1097 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1129 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1015 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEH5 – Monaro.

Landscape 1136 is an area of high ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEC3 – Bateman.

Landscape 1161 is an area of moderate ruggedness with a dominant geology of coastal sands occurring in subregion SEC2 – South East Coastal Ranges.

Profiles of Landscapes 948, 949, 1012, 1016, 1017, 1064, 1090, 1092, 1096, 1112, 1143 and 1145

Landscape 948 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SEH7 – Bungonia.

Landscape 949 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH7 – Bungonia.

Landscape 1012 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB13 – Ettrema.

Landscape 1016 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB13 – Ettrema.

Landscape 1017 is an area of high ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB13 – Ettrema.

Landscape 1064 is an area of high ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SB13 – Ettrema.

Landscape 1090 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEC3 – Bateman.

Landscape 1092 is an area of high ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SEC3 – Bateman.

Landscape 1096 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEC3 – Bateman.

Landscape 1112 is an area of high ruggedness with a dominant geology of acid igneous intrusives occurring in subregion AA1 – New South Wales Alps.

Landscape 1143 is an area of high ruggedness with a dominant geology of sedimentary (calcareous) occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1145 is an area of moderate ruggedness with a dominant geology of sedimentary (calcareous) occurring in subregion SEC2 – South East Coastal Ranges.

Profiles of Landscapes 1129, 1094, 1134, 1132, 1095, 1097 and 1133

Landscape 1129 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1094 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1134 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1132 is an area of high ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1095 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1097 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEC2 – South East Coastal Ranges.

Landscape 1133 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEC2 – South East Coastal Ranges.

Profiles of Landscapes 1109 and 1076

Landscape 1109 is an area of high ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH5 – Monaro.

Landscape 1076 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH5 – Monaro.

Profiles of Landscapes 1008, 1140, 1099 and 1100

Landscape 1008 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEH5 – Monaro.

Landscape 1140 is an area of low ruggedness with a dominant geology of coastal sands occurring in subregion SEC3 – Bateman.

Landscape 1099 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEC3 – Bateman.

Landscape 1100 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEC3 – Bateman.

Wildlife refuges

Twelve landscapes (1135, 1141, 1140, 1159, 1099, 1094, 1134, 1129, 1100, 1133, 1097 and 1128) are represented in wildlife refuges. All are also represented in the reserve system. These range from low to moderate ruggedness and with a variety of geology and originate in the Bateman and the South East Coastal Ranges subregions.

Crown reserves

Seven landscapes with a range of ruggedness and geology are represented in crown reserves. All but one have less than 2% of their bioregional area represented in crown reserves and are also represented in the reserve system. These landscapes are:

- Landscape 1133 with 10.30 ha or 0.01% of its bioregional area; -
- Landscape 1132 with 15.51 ha or 0.05% of its bioregional area; -
- Landscape 1129 with 17.89 ha or 0.01% of its bioregional area;
- Landscape 1094 with 72.30 ha or 0.03% of its bioregional area; -
- Landscape 1097 with 137.08 ha or 0.09% of its bioregional area; -
- Landscape 1109 with 171.72 ha or 4.29% of its bioregional area; and
- Landscape 1076 with 423.60 ha or 1.58% of its bioregional area. -

Property agreements

Five landscapes are represented in property agreements. They occupy landscapes within the South East Coastal Ranges, Monaro and Bateman subregions and are all of low ruggedness with a variety of geology. All are also represented in the reserve system and have less than 1% of the bioregional area of the landscape included in the program. These landscapes are:

- Landscape 1097 with 4.70 ha or <0.01% of its bioregional area; -
- Landscape 1008 with 7.05 ha or 0.03% of its bioregional area; -
- Landscape 1134 with 14.03 ha or 0.11% of its bioregional area;
- Landscape 1140 with 23.69 ha or 0.99% of its bioregional area; -
- Landscape 1099 with 34.66 ha or 0.04% of its bioregional area; and -
- Landscape 1100 with 59.29 ha or 0.49% of its bioregional area. -

Flora reserves

Seventeen landscapes are represented in flora reserves (1084, 1133 ,1099, 1155, 1098, 1008, 1166, 1035, 1095, 1129, 1102, 1164, 1165, 1162, 1094, 1097, 1163). They have a variety of ruggedness (low to high), varying geology and source subregions are the East Gippsland Lowlands, South East Coastal Ranges, Monaro and Bateman. All are also represented in the reserve system. One landscape, Landscape 1166, an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SEC1 – East Gippsland Lowlands (EGL), has 23.48% of its bioregional area represented in flora reserves while also having a 20% representation in the reserve system.

Conservation and clearing

About 251,700 ha or 19.42% of the South East Corner Bioregion has been cleared.

Thirty-nine of the landscapes have some clearing of the native canopy indicated. Landscape 1060 is indicated as 100% cleared and a further two have greater than 70% of their area cleared while a total of 14 have greater and equal to 50% of their landscape cleared. Only 3 landscapes, 1015, 1136, and 1161, are not represented in the reserve system (nor in any other of the conservation tenures). Only 5 landscapes have greater than 20% of their bioregional area reserved. Surprisingly Landscape 1060 has 100% cleared and a 39.64% inclusion in reserve.

SOUTH EASTERN HIGHLANDS

Landscape-scale conservation

There are 281 landscapes in the South Eastern Highlands (NPWS in prep).

Despite the large number of landscapes, 2 low ruggedness landscapes (1008 and 1025) dominate 21.20% of the bioregion. Of the 281, a relatively large proportion, 226, are included in conservation tenures.

National parks and nature reserves

A total of 596,638.58 ha or 12.22% of the bioregion is included in the reserve system and 194 of the 281 landscapes are represented in this system. Ninety-nine landscapes have greater than 20% of their area included in this system. Of this group, 10 (mostly but not all are relatively small eg 100ha) landscapes have 100% of their bioregional area included in the reserve system, a further 13 have between 90 and 99%, 12 have between 80 and 89% and 12 between 70 and 79%.

Historic site

Four landscapes are represented in historic sites in the bioregion. These are:
- Landscape 846 with 136 ha or 0.02% of its bioregional area;
- Landscape 829 with 10.16 ha or 0.30% of its bioregional area;
- Landscape 731 with 12.41 ha or 0.10% of its bioregional area ; and
- Landscape 768 with 104.82 ha or 0.14% of its bioregional area.

All of these landscapes are also represented in the national parks and nature reserves of the bioregion.

Karst conservation reserves

Seven landscapes are represented in the karst conservation reserves of the bioregion. Only one of these landscapes (Landscape 779) is not also represented in the system of national parks and nature reserves. Those landscapes represented in the karst conservation reserves are:
- Landscape 779 with 124.71 ha or 0.52% of its bioregional area;
- Landscape 944 with 222.66ha or 0.56% of its bioregional area; -
- Landscape 901 with 271.69ha or 2.12% of its bioregional area; -
- Landscape 852 with 421.09ha or 2.67% of its bioregional area;
- Landscape 898 with 447.35ha or 3.15% of its bioregional area; -
- Landscape 895 with 542.31ha or 41.72% of its bioregional area; and -
- Landscape 891 with 1383.24ha or 13.83% of its bioregional area. -

Crown reserves

Thirty-nine landscapes are represented in the NPWS-managed Crown reserves in the bioregion. All of these have some representation in the system of national parks and nature reserves.

State recreation area

Nineteen landscapes are represented in the state recreation areas in the bioregion. Two landscapes, 779 and 775 that are represented in SRAs are not also represented within the system of national parks and nature reserves. Landscape 779 has 385.22 ha or 1.59% of its bioregional area included and 775 has 644.23 ha or 5.97% included.

Profiles of landscapes 1008 and 1025

Landscape 1008 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEH5 – Monaro.

Landscape 1025 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH5 – Monaro.

Profiles of Landscapes 846, 829, 731 and 768

Landscape 846 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB9 – Burragorang.

Landscape 829 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEH11 – Bathurst.

Landscape 731 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SEH13 – Hill End.

Landscape 768 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SEH13 – Hill End State Recreation Area.

Profiles of Landscapes 779, 944, 901, 852, 989, 895 and 891

Landscape 779 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH12 – Orange.

Landscape 944 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH7 – Bungonia.

Landscape 901 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH9 – Crookwell.

Landscape 852 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH10 – Oberon.

Landscape 898 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH9 – Crookwell.

Landscape 895 is an area of high ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH8 – Kanangra.

Landscape 891 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH8 – Kanangra.

Profiles of Landscapes 690, 775 and 779

Landscape 690 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB4 – Wollemi.

Landscape 775 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH12 – Orange.

Landscape 779 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH12 – Orange.

Profiles of Landscapes 974, 951 and 832

Landscape 974 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SEH6 – Murrumbateman.

Landscape 951 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH6 – Murrumbateman.

Landscape 832 is an area of low ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SEH11 – Bathurst

Flora reserves

Twenty-one landscapes are represented in the flora reserves of the bioregion. Three of these, landscapes 775, 779 and 690, are not represented in the system of national parks and nature reserves. They are:

- Landscape 779 with 12.54 ha or 0.05% of its bioregional area;
- Landscape 775 with 155.61 ha or 1.44% of its bioregional area; and
- Landscape 690 with 50.09 ha or 0.42% of its bioregional area.

Voluntary conservation agreements

Twenty-five landscapes are included in voluntary conservation agreements in the bioregion. Although relatively small in area conserved, 3 of these landscapes are not represented in the reserve system. These are:

- Landscape 974 with 12.91 ha or 1.29% of its bioregional area;
- Landscape 951 with 48.06 ha or 0.72% of its bioregional area; and
- Landscape 832 with 4.65 ha or 0.42% of its bioregional area.

Wildlife refuges

A relatively large range of landscapes (100) is included in the wildlife refuges of the bioregion. Wildlife refuges significantly expand the range of landscapes protected with the inclusion of 24 landscapes that are not represented in the system of national parks and nature reserves.

Property agreements

Eighty landscapes (60 of which are also represented in the wildlife refuge program) are represented in the conservation zones of property agreements in the bioregion. The property agreement program adds a range of landscapes to those protected in national parks and nature reserves in the bioregion. Thirteen landscapes managed in the conservation zone of property agreements are not represented in the reserve system.

Special catchment areas

Ten landscapes are included in special catchment areas that are not gazetted as national park or nature reserve.

Conservation and clearing

While landscapes are by no means comprehensively reserved in the bioregion, a relatively large range has greater than 20% representation in the reserve system. The range of landscapes under some form of conservation management is most expanded by wildlife refuges and then by property agreements.

About 2,823,700 ha, or 57.87% of the bioregion has been cleared. Only 51 of the 281 landscapes appear to have had no clearing of their native canopy. More than half (180) have more than 30% of their canopy cleared. Of this group, 21 are 100% cleared, and 68 have between 70 and 99% of their canopy cleared. Over half of those with some level of clearing do have representation in national parks and nature reserves. Forty-five of the landscapes have more than 30% of their canopy cleared and have no representation in any of the conservation tenures.

SYDNEY BASIN

Landscape-scale conservation

The Sydney Basin Bioregion is covered by 241 landscapes (NPWS in prep). The majority of the landscapes occupy less than 1% of the bioregion, and the dominant landscape is Landscape 690, occupying 401,000 ha or 11.24% of the bioregion.

National parks and nature reserves

One hundred and seventy-eight of the 240 landscapes in the Sydney Basin are included in the system of national parks and nature reserves. Ninety-four landscapes have greater than 20% of their bioregional area included in the reserve system. Eight landscapes across the full range of ruggedness and with varying geology have 100% of their area included. Thirteen landscapes of variable type have between 90 and 99% of their area included in national parks and nature reserves and 39 landscapes have between 50 and 89% of their bioregional area included in the reserve system (eight between 80 and 89%, 11 between 70 and 79%, 8 between 60 and 69% and 12 between 50 and 59%). Landscape 690, the dominant landscape (by area), is also the most highly reserved landscape in terms of area reserved, with 311235.71 ha or 77.61% of its bioregional area contained in the reserve system.

Historic sites

Five low to moderate ruggedness sedimentary or alluvial landscapes are represented in historic sites in the bioregion. As is usually the case, historic sites involve only small areas and percentages of landscapes. Each of these landscapes is also represented to a greater or lesser degree in the reserve system. These landscapes are:

- Landscape 733 with 2.45 ha or <0.01% of its bioregional area;
- Landscape 748 with 2.93 ha or 0.08% of its bioregional area; -
- Landscape 742 with 18.44 ha or 0.18% of its bioregional area; -
- Landscape 732 with 30.43 ha 0.02% of its bioregional area; and
- Landscape 987 with 73.98 ha or 0.19% of its bioregional area. -

Aboriginal areas

Seven landscapes with varying ruggedness and geology are represented in Aboriginal areas. A greater area of the landscapes included in Aboriginal areas are represented in the reserve system, while two of the landscapes have greater than half of their bioregional area protected within national parks and nature reserves. The areas and proportion of each of these landscapes is listed below:

- Landscape 733 with 0.64 ha or <0.01% of its bioregional area; -
- Landscape 1087 with 2.98 ha or 0.05% of its bioregional area;
- Landscape 701 with 3.58 ha or <0.01% of its bioregional area; -
- Landscape 732 with 4.77 ha or <0.01% of its bioregional area; -
- Landscape 806 with 6.98 ha or 0.02% of its bioregional area;
- Landscape 809 with 9.27 ha or 0.02% of its bioregional area; and -
- Landscape 1060 with 44.36 ha or 1.48% of its bioregional area. -

State recreation areas

Fifty-three of the Sydney Basin landscapes are represented in the state recreation areas. One hundred per cent of Landscape 955 (a relatively small landscape of 200 ha) is included in these areas. Only one other landscape, the moderate ruggedness alluvial Landscape 972 (which at 0.02 ha is the most minimally represented in the SRA), is not also represented in national parks and nature reserves.

Landscape 690 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB4 – Wollemi.

Profile of Landscapes 733, 748, 742, 732 and 987

Landscape 733 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB5 – Yengo.

Landscape 748 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SB5 – Yengo.

Landscape 742 is an area of moderate ruggedness with a dominant geology of eastern alluvials occurring in subregion SB5 – Yengo.

Landscape 732 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB5 – Yengo.

Landscape 987 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB11 – Moss Vale.

Profiles of Landscapes 955 and 972

Landscape 955 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH7 – Bungonia.

Landscape 972 is an area of moderate ruggedness with a dominant geology of eastern alluvials occurring in subregion SB12 – Illawarra.

Profiles of Landscapes 782, 739, 858, 848 and 781

Landscape 782 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SB4 – Wollemi.

Landscape 739 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB4 – Wollemi.

Landscape 858 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SB8 – Cumberland.

Landscape 848 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB8 – Cumberland.

Landscape 781 is an area of moderate ruggedness with a dominant geology of eastern alluvials occurring in subregion SB4 – Wollemi.

Profiles of Landscapes 869, 880, 850, 809 and 806

Landscape 869 is an area of moderate ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB7 – Pittwater.

Landscape 880 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB7 – Pittwater.

Landscape 850 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB8 – Cumberland.

Landscape 809 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB7 – Pittwater.

Landscape 806 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB7 – Pittwater.

Profiles of Landscapes 456, 638, 975, 992, 1012, 994, 989, 1000, 1023, 1038 and 1011

Landscape 456 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion BBS24 – Pilliga.

Landscape 638 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB1 – Kerrabee.

Landscape 975 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB12 – Illawarra.

Landscape 992 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB11 – Moss Vale.

Landscape 1012 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB13 – Ettrema.

Landscape 994 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB11 – Moss Vale.

Landscape 989 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB12 – Illawarra.

Landscape 1000 is an area of high ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB11 – Moss Vale.

Landscape 1023 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB13 – Ettrema.

Landscape 1038 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SB13 – Ettrema.

Landscape 1011 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB13 – Ettrema.

Regional parks

The Sydney Basin Bioregion is the only one to provide regional parks to urbanised areas of the bioregion. Ten low to moderate ruggedness landscapes with sedimentary or alluvial geology are represented in the regional parks of the Sydney Basin Bioregion. The areas and proportion of each represented in these parks are listed below. All are represented to a greater degree in the system of national parks and nature reserves.

- Landscape 782 with 5.06 ha or 0.09% of its bioregional area; -
- Landscape 739 with 31.46 ha or 0.04% of its bioregional area;
- Landscape 858 with 111.82 ha or 0.21% of its bioregional area; -
- Landscape 848 with 155.71 ha or 0.47% of its bioregional area; -
- Landscape 781 with 190.06 ha or 5.76% of its bioregional area;
- Landscape 869 with 266.25 ha or 38.04% of its bioregional area; -
- Landscape 880 with 276.45 ha or 6.14% of its bioregional area; -
- Landscape 850 with 699.34 ha or 0.39% of its bioregional area;
- Landscape 809 with 1412.05 ha or 2.78% of its bioregional area; and -
- Landscape 806 with 1524.74 ha or 3.31% of its bioregional area. -

Crown reserves

The area of Crown reserves managed by the National Parks and Wildlife Service in the Sydney Basin Bioregion encompasses 11 landscapes. While the geology of these landscapes is primarily sedimentary, the ruggedness varies. All are well represented in the system of national parks and nature reserves and only 2 (456 and 975) have less than 20% of their area included in national parks and nature reserves.

- Landscape 456 with 0.09 ha or <0.01% of its bioregional area; -
- Landscape 638 with 3.63 ha or <0.01% of its bioregional area;
- Landscape 975 with 6.65 ha or 0.03% of its bioregional area; -
- Landscape 992 with 10.37 ha or 0.07% of its bioregional area; -
- Landscape 1012 with 19.79 ha or 0.06% of its bioregional area;
- Landscape 994 with 19.95 ha or 0.34% of its bioregional area; -
- Landscape 989 with 43.33 ha or 1.14% of its bioregional area; -
- Landscape 1000 with 85.52 ha or 17.10% of its bioregional area;
- Landscape 1023 with 153.93 ha or 0.48% of its bioregional area; -
- Landscape 1038 with 176.32 ha or 25.19% of its bioregional area; and -
- Landscape 1011 with 680.36 ha or 0.98% of its bioregional area. -

Flora reserves

Twelve landscapes are included in flora reserves in the Sydney Basin Bioregion. The majority (but not all) are on low to moderate ruggedness with a sedimentary geology and are sourced from a few subregions. Only one (landscape 772) does not occur in the system of national parks and nature reserves. Eight of the 11 landscapes have less than 20% of their area represented. Given the relatively high security of flora reserves, their contribution towards management of landscapes with low reservation status is important.

- Landscape 772 with 1.28 ha or 0.64% of its bioregional area;
- Landscape 749 with 4.81 ha or 0.04% of its bioregional area;
- Landscape 691 with 4.94 ha or 0.01% of its bioregional area;
- Landscape 920 with 10.82 ha or 0.07% of its bioregional area;
- Landscape 986 with 18.98 ha or 0.12% of its bioregional area;
- Landscape 696 with 36.00 ha or 0.47% of its bioregional area;
- Landscape 757 with 68.72 ha or 1.21% of its bioregional area;
- Landscape 919 with 78.84 ha or 0.18% of its bioregional area;
- Landscape 589 with 97.64 ha or 0.28% of its bioregional area;
- Landscape 747 with 157.54 ha or 0.27% of its bioregional area;
- Landscape 846 with 178.80 ha or 0.78% of its bioregional area; and
- Landscape 690 with 482.87 ha or 0.12% of its bioregional area.

Voluntary conservation agreements

VCAs on land in the Sydney Basin cross 12 landscapes. The majority of these landscapes are of low to moderate ruggedness with sedimentary geology, and the source subregions vary. As with VCAs generally, the areas conserved are relatively small although one landscape (Landscape 993), a low ruggedness igneous landscape, is not represented in the system of national parks and nature reserves and seven others (927, 937, 858, 717, 850, 848 and 975) have lower than 20% representation in this system.

- Landscape 975 with 0.35 ha or <0.01% of its bioregional area;
- Landscape 993 with 1.08 ha or 0.01% of its bioregional area;
- Landscape 732 with 10.10 ha or 0.01% of its bioregional area;
- Landscape 1011 with 10.67 ha or 0.02% of its bioregional area;
- Landscape 848 with 14.40 ha or 0.04% of its bioregional area;
- Landscape 850 with 18.13 ha or 0.01% of its bioregional area;
- Landscape 996 with 19.54 ha or 0.53% of its bioregional area;
- Landscape 992 with 21.97 ha or 0.16% of its bioregional area;
- Landscape 717 with 65.63 ha or 0.20% of its bioregional area;
- Landscape 858 with 77.55 ha or 0.14% of its bioregional area;
- Landscape 937 with 85.03 ha or 0.27% of its bioregional area; and
- Landscape 927 with 279.59 ha or 0.29% of its bioregional area.

Profiles of landscapes 975, 993, 732, 1011, 848, 850, 996, 992, 717, 858, 937 and 927

Landscape 975 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB12 – Illawarra.

Landscape 993 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SB12 – Illawarra.

Landscape 732 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB5 – Yengo.

Landscape 1011 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB13 – Ettrema.

Landscape 848 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB8 – Cumberland.

Landscape 850 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB8 – Cumberland.

Landscape 996 is an area of high ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SB12 – Illawarra.

Landscape 992 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB11 – Moss Vale.

Landscape 717 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB5 – Yengo.

Landscape 858 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SB8 – Cumberland.

Landscape 937 is an area of moderate ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB10 – Cataract.

Landscape 927 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB10 – Cataract.

Profiles of Landscapes 610, 680, 1019, 1039 and 997

Landscape 610 is an area of low ruggedness with a dominant geology of acid igneous intrusives occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 680 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion NSS1 – Northern Inland Slopes (NIS), Upper Slopes.

Landscape 1019 is an area of moderate ruggedness with a dominant geology of acid volcanics (extrusives) & associated sediments occurring in subregion SB12 – Illawarra.

Landscape 1039 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SB13 – Ettrema.

Landscape 997 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SB11 – Moss Vale.

Profiles of Landscapes 985, 850, 989, 746, 990, 747, 986, 975, 987 and 998

Landscape 985 is an area of moderate ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB11 – Moss Vale.

Landscape 850 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB8 – Cumberland.

Landscape 989 is an area of high ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB12 – Illawarra.

Landscape 746 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB6 – Wyong.

Landscape 990 is an area of low ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SB11 – Moss Vale.

Landscape 747 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB6 – Wyong.

Landscape 986 is an area of low ruggedness with a dominant geology of sedimentary (coarse grain) occurring in subregion SB11 – Moss Vale.

Landscape 975 is an area of moderate ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB12 – Illawarra.

Landscape 987 is an area of low ruggedness with a dominant geology of sedimentary (fine grain-non calcareous) occurring in subregion SB11 – Moss Vale.

Landscape 998 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SB12 – Illawarra.

Wildlife refuges

Sixty-five landscapes are represented in the wildlife refuge program. This makes it the second (one landscape less than special catchment areas) largest contributor (albeit a less certain contribution than special catchment areas both in terms of security and degree of active management) to conservation tenures outside the reserve system. Six of these are not represented in national parks and nature reserves. Another 31 have less than 20% of their bioregional area included in this system of reserves. Landscapes not also represented in national parks and nature reserves include:

- Landscape 610 with 130.38 ha or 9.31% of its bioregional area; -
- Landscape 993 with 47.80 ha or 0.33% of its bioregional area; -
- Landscape 680 with 17.49 ha or 5.83% of its bioregional area;
- Landscape 1019 with 17.52 ha or 17.52% of its bioregional area; -
- Landscape 1039 with 3.19 ha or 0.53% of its bioregional area; and -
- Landscape 997 with 139.33 ha or 5.57% of its bioregional area. -

Property agreements

Seventeen landscapes have been included in property agreements. A small area (4.54 ha or 0.18% of its bioregional area) of one landscape (997), which is also represented in the wildlife refuge program, does not also occur in the reserve system. Ten others have less than 20% representation in the reserve system; their areas, proportions and descriptions are included below and in the text box.

- Landscape 985 with 0.14 ha or <0.01% of its bioregional area;
- Landscape 850 with 0.60 ha or <0.01% of its bioregional area; -
- Landscape 989 with 0.63 ha or 0.02% of its bioregional area; -
- Landscape 746 with 1.38 ha or <0.01% of its bioregional area;
- Landscape 990 with 2.77 ha or 0.03% of its bioregional area; -
- Landscape 747 with 2.78 ha or <0.01% of its bioregional area; -
- Landscape 986 with 5.46 ha or 0.04% of its bioregional area;
- Landscape 975 with 16.40 ha or 0.08% of its bioregional area; -
- Landscape 987 with 18.15 ha or 0.05% of its bioregional area; and -
- Landscape 998 with 147.76 ha or 0.74% of its bioregional area. -

Special catchment areas

Sixty-six landscapes are included in these lands. Six of these landscapes have no representation in the reserve system and 27 others have less than 20% of their area included in the reserve system. The areas and proportion of landscape included in SCA lands where these are not also represented in the reserve system are listed below:

- Landscape 999 with 13.20 ha or 6.60% of its bioregional area; -
- Landscape 885 with 98.78 ha or 98.78% of its bioregional area;
- Landscape 964 with 99.85 ha or 49.93% of its bioregional area; -
- Landscape 997 with 664.02 ha or 26.56% of its bioregional area; -
- Landscape 988 with 799.13 ha or 88.79% of its bioregional area; and
- Landscape 962 with 1765.36 ha or 73.56% of its bioregional area. -

Conservation and clearing

Almost one third, 1,173,400 ha or 32.9% of the Sydney Basin Bioregion, has been cleared of native canopy vegetation. Just under half (119) of the 241 landscapes are more than 30% cleared (25 are 100% cleared, 33 in the 70-99% range of clearing, 30 in the 50-70% clearing range and 32 between 30 and 49% cleared). Forty-nine of the landscapes in the Sydney Basin are not included in any conservation tenures and only 71 of those landscapes in the 30-99% clearing range are included in the system of national parks and nature reserves. Those landscapes having low representation in the more secure forms of conservation management (national parks/nature reserves, flora reserves, voluntary conservation agreement and property agreement, if perpetual, and particularly those which are highly cleared) are priorities for conservation or restoration.

Profiles of Landscapes 999, 885, 964, 997, 988 and 962

Landscape 999 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB11 – Moss Vale.

Landscape 885 is an area of moderate ruggedness with a dominant geology of acid igneous intrusives occurring in subregion SEH8 – Kanangra.

Landscape 964 is an area of moderate ruggedness with a dominant geology of eastern alluvials occurring in subregion SB10 – Cataract.

Landscape 997 is an area of low ruggedness with a dominant geology of eastern alluvials occurring in subregion SB11 – Moss Vale.

Landscape 988 is an area of moderate ruggedness with a dominant geology of basic/intermediate igneous & associated sediments & metasediments occurring in subregion SB10 – Cataract.

Landscape 962 is an area of low ruggedness with a dominant geology of sedimentary (mixed grain) occurring in subregion SB10 – Cataract.

Glossary -

Acid volcanics	Light coloured volcanic rocks containing more than 66% silica, free quartz and a minimum of dark coloured minerals.
Aeolian	Moved by the wind.
Alluvial	Deposited by streams.
Alluvial fan	Fan shaped alluvial deposit of sediment where streams disperse after leaving confined valleys. Steepness (gradient) relates to sediment grain size.
Amphibolite	Metamorphic rock composed essentially of amphiboles or dark coloured minerals such as hornblende. Usually derived from submarine basalt.
Anabranch	Branch of an anastomosing stream that leaves the main channel and rejoins it some distance down stream.
Anastomosing	Multi-branched stream system.
Backplain	Parts of a river floodplain furthest from the channel.
Barrier	See coastal barrier.
Basalt	Dark coloured, fine grained volcanic rock composed of olivine, pyroxene and feldspar. No free quartz.
Basement rock	General term to describe older rocks beneath a sedimentary basin.
Bedrock	Hard rock beneath a superficial cover of soils and sediments.
Black earth	Dark coloured pedal clay soils usually found in valleys and often derived from basalt.
Blockstream	Periglacial landform composed of a "river" of boulders on low angle slopes.
Braided river	River in which the main channel is braided with multiple paths that split and join frequently. Usually a gravel or sand bed stream.
Caldera	Large volcanic crater created by explosion or internal collapse of a volcanic cone.
Cambrian	Period of geologic time 500-570 million years ago.
Carboniferous	Period of geologic time 280-345 million years ago.
Cauldron subsidence	See caldera.
Central volcano	A single major volcanic vent responsible for a large area of volcanic rocks.
Chert	Fine grained siliceous rock usually formed in deep sea environments either as a chemical precipitate, or as accumulated remains of siliceous single celled organisms such as radiolaria.
Cirque	Small glaciers and the basins they excavate at the head of valleys.
Claystone	Sedimentary rock composed of clay. Also referred to as mudstone.
Cliff top dunes	Sand dunes located well above the beach from which the sand was derived.
Coastal barrier	Complex landscape of beach, dunes and enclosed lagoon or swamps that form between headlands during rising sea levels.
Colluvial	The movement and deposition of sediment and debris on slopes.
Columnar lava	Basalt or other volcanic rocks with well developed columns (organ pipes) formed by cooling joints.
Competence	The ability of a stream to carry sediment of different size.
Conglomerate	Sedimentary rock composed of particles coarser than sand, for example, pebbles.
Contact metamorphic	Metamorphic change induced in rock that comes in contact with a heat source such as a granite intrusion.
Continental shelf	Shallow seas adjacent to the continent. Most were exposed during times of low sea level in the Pleistocene ice age.
Contour banding	Alternating zones of different soil, sediment and vegetation approximately following the contour on gentle slopes in the arid zone. Often stony and stone-free bands.
Cracking clay	Alluvial clays with high shrink/swell potential that crack deeply on drying.
Cretaceous	Period of geologic time 65-136 million years ago.
Debris dam	Floating load debris (logs etc.,) that have accumulated across a river channel and that may divert the stream.

Dendritic	Multiple branching pattern like a tree.
Desert pavement	Lag gravel surface of gibbers (pebbles and boulders) on the soil surface.
Devonian	Period of geologic time 345-395 million years ago.
Diatomite	Very light weight sedimentary rock composed of the remains of diatoms.
Diatreme	Pipe like vertical volcanic vent filled with broken and cemented country rock created by a single explosion.
Dip-slope escarpment	Asymmetric landform where rock bedding controls the cross-sectional shape of ridges. Cliffed on one side with a gentle slope following the dip of bedding planes on the other side.
Discharge	Volume of water flowing past a point in a stream over time.
Dolerite	Medium grained igneous rock with composition similar to basalt. Usually found in dykes or sills.
Downs	Extensive undulating and gently rolling plains.
Dune	Sand accumulating and moving in dune forms.
Dyke	Vertical sheet of intrusive igneous rock.
Endemic	Restricted distribution.
Ephemeral	Lasting only a short time.
Escarpment	A cliff or the steep slopes of a plateau edge.
Fault	Fracture zone in rock along which there has been movement of the crust.
Feldmark	Community of prostrate plants growing on a stony pavement in an extreme alpine environment.
Floodout	Area of an alluvial fan where the stream disperses across a plain.
Fold belt	Region in which all the bedrock has been subject to similar phases of disturbance by folding and faulting.
Footslope	Lower part of a hillslope merging with the alluvial plain.
Gabbro	Coarse grained igneous rock with composition similar to basalt.
Gibber	Stones in a desert pavement.
Gilgai	Hummocky micro-relief pattern common in heavy alluvial clays.
Glacio-marine	Poorly sorted sandstones and conglomerates formed in an environment where icebergs move glacial debris offshore.
Gneiss	High grade, coarse grained metamorphic rock with an overall composition similar to granite.
Gondwana	Name given to the super continent formed when Australia, Antarctica, Africa, India and South America were all joined.
Gorge	Steep narrow river valley.
Gradational Soil	A soil with a gradual increase in texture (ie. becomes more clayey) as the profile deepens.
Granite	Light coloured, coarse grained plutonic rock with free quartz. Usually composed of potassium feldspar, quartz and mica.
Granodiorite	Coarse grained plutonic rock, similar to granite but with less quartz and more dark minerals.
Great Artesian Basin	Extensive area of inland Australia filled with Mesozoic sedimentary rocks and containing an important resource of artesian water.
Great Dividing Range	Eastern highlands of Australia that separate coastal streams from those flowing inland and particularly the Murray-Darling Basin.
Great Escarpment	Eastern margin of the Great Dividing Range where the most rugged topography is found.
Groundwater window	Place where the topography is lower than the groundwater table and a lake or salina forms.
Guano	Accumulation of bird (or bat) faeces and the soil it interacts with.
Gypsum	A common mineral of evaporates in inland salt playas. Calcium sulphate
Harsh clay	Hard, dense clay with high shrink/swell potential and highly dispersible. See also: Mellow clay.
Horizon	Layers in a soil formed by surface processes, by convention A and B horizons are equivalent to topsoil and subsoil.

Hypersaline	Very saline brines. Salt concentration greater than sea water.
Igneous	Rocks formed from melts in the Earth's crust. eg. Granite, gabbro or basalt.
Inner barrier	Older coastal barrier system sometimes found on the landward side of the outer (or modern) barrier.
Intrusives	Igneous rocks that have intruded other rocks. eg. A granite body or an igneous dyke.
Island arc	Complex of volcanic islands, and shallow seas adjacent to an oceanic trench. For example, Indonesia.
Joints	Natural fractures in a body of rock that cause it to break into regular blocks on weathering or when quarried.
Jurassic	Period of geologic time 136-190 million years ago.
Karst	Landforms created by solution of rock in which most of the drainage is by underground channels that may lead to the formation of caves. Normally refers to limestone karst but can occur in other rock types.
Lava field	Extensive area of volcanic rock derived from many small volcanic vents rather than a central volcano.
Leucitite	Rare basalt dominated by the felspathoid leucite, rather than the more common calcic plagioclase.
Lignite	Soft brown coal.
Limestone	Any sedimentary rock composed essentially of calcium carbonate.
Linear dunes	Sand dunes forming regular lines oriented parallel to dominant winds.
Lithic sandstone	Sandstone composed of sand sized rock fragments.
Loam	Soil material with approximately equal quantities of sand, silt and clay.
Lunette	Crescent shaped beach and dune complex found on the eastern sides of lakes in arid Australia. Usually composed of quartz sand but can also be partly or wholly composed of sand sized clay pellets and occasionally gypsum sand (copi or seed gypsum).
Meander	River with a single channel that sweeps back and forth in smooth curves.
Mellow clay	A soft stable clay with minimum shrinkage potential.
Mesa	Small flat topped hill. See also Tableland.
Mesozoic	Era of geologic time 65-225 million years ago.
Metamorphic	Any rock formed from a pre-existing rock by application of heat and pressure. For example, quartzite, slate, schist, or gneiss.
Meta-sediments	Low grade metamorphic rock derived from sedimentary rocks and retaining some original structure or composition.
Monocline	One sided fold in a geological basin.
Monzonite	Coarse grained igneous of the granite type.
Mound spring	Point of surface flow of artesian water. Mounds normally formed by concentration of soluble minerals.
Mulga groves	Contour banded pattern of mulga growth on extensive sandplains.
Ordovician	Period of geologic time 430-500 million years ago.
Overflow lakes	Lakes fed by floodwaters from a stream.
Pagoda country	Sandstone landscapes formed by erosion with tall rock pillars that look like pagodas.
Palaeo-drainage	Abandoned river patterns evident in the landscape formed under different climatic conditions.
Palaeozoic	Era of geologic time 225-570 million years ago.
Parabolic dunes	Curved dune patterns oriented parallel to dominant winds. May be a pre-cursor to linear dunes.
Pedal	Natural aggregates in soils, often with a geometric shape. eg. blocky or prismatic.
Pegmatite	Very coarse grained rocks of granitic composition containing large mineral crystals.
Peneplain	A lowland plain formed by erosion to the extent that rock structure and composition no longer influence the landscape. Supposed to be the end phase of an erosion cycle, which is an old concept that is not universally accepted.
Periglacial	Environments dominated by ground ice and freeze/thaw processes, as in the tundra.

Permian	Period of geologic time 225-280 million years ago.
Phyllite	Fine grained metamorphic rock with well developed cleavage, derived from shale.
Pillow lava	Volcanic rock with unusual pillow structure caused by lava cooling under water.
Plateau	Generally high ground with more or less concordant summits and low relative relief.
Playa	Clay plain that is temporarily flooded to form a lake or swamp after exceptional rainfall.
Pleistocene	Epoch of geologic time 10,000 to 1.8 million years ago.
Pliocene	Epoch of geologic time 1.8 - 5 million years ago.
Ploughing block	Large boulder moved through the soil mantle by periglacial processes, or by high snow loads.
Plugs	Bodies of igneous rock that have cooled in the throat of a volcano and subsequently been exposed by erosion. Often columnar jointed.
Podsol	Soil profile with distinctive horizons of a bleached lower topsoil and cemented iron oxide pans in the subsoil. Formed in quartz sand under special conditions and special vegetation. Common in coastal dunes.
Porphyry	Any igneous rocks with a porphyritic texture, that is, coarse crystals in a fine groundmass. Indicates that two phases of cooling were involved.
Prior streams	Relic channels and channel traces on an alluvial fan created by streams in a different climate.
Psuedokarst	Cave-like land forms and features in non-soluble rocks such as granite boulders.
Quartz sandstone	Sandstone composed largely of quartz sand grains.
Quartzite	Metamorphosed quartz sandstone.
Quartzose	General term for a sedimentary rock composed of quartz grains that is intermediate between a quartz sandstone and a quartzite.
Quaternary	Period of geologic time 0-1.8 million years ago.
Rain shadow	Area of low average rainfall such as the region behind a mountain range.
Regolith	All layers of weathered rock, sediments and soil material covering the surface.
Residual	A soil material or landform that remains in place from the past.
Rhyolite	Fine grained, light coloured volcanic rock with a high proportion of quartz, equivalent in composition to granite.
Rock platforms	Coastal rock benches in the inter-tidal zone.
Runoff	Precipitation that flows across the ground surface and enters streams leading to lakes or oceans.
Run-on sites	Parts of footslopes or alluvial fans that receive runoff from upper slopes.
Sandplains	Extensive sheets of aeolian sand that do not exhibit dune forms.
Sandstone	Sedimentary rock composed of sand sized particles.
Scarp	See Escarpment
Schist	Foliated, high grade metamorphic rock
Sedimentary	Rocks composed of sediments. For example, claystone, sandstone, conglomerate.
Serpentinite	A green metamorphic rock composed of hydrated magnesium silicates formed by the alteration of olivines and pyroxenes usually in a submarine environment.
Shale	Sedimentary rock composed of silt and clay sized particles, weakly cemented.
Shield volcano	Very large composite and symmetric volcano.
Silcrete	Fine grained orthoquartzite formed by cementation of shale or siltstone with silica.
Sill	Horizontal sheet of intrusive igneous rock.
Silurian	Period of geologic time 395-430 million years ago.
Slate	Fine grained metamorphic rock with perfect cleavage formed by metamorphism of shale.
Snow patch	Area of persistent summer snow on a protected aspect.
Solifluction lobes	Lobes and bulges of deformed soil and vegetation on hillslopes subject to periglacial activity.

Structure	Overall geometry of folds, faults and joint patterns in a rock mass.
Subsoil	B horizon usually derived from rock by in situ weathering.
Swale	Valley between dunes.
Tableland	Large flat top hill, extended mesa or small plateau. Also used to describe a plateau.
Terminal channels	River channels that terminate in an inland region without reaching the sea or a lake.
Terraces	Level areas of valley floors that are not flooded. - Abandoned floodplains. -
Tertiary	Period of geologic time 1.8-65 million years ago.
Texture contrast profile	Soil profile in which the topsoil (A horizon) has a sandier texture than the subsoil (B horizon). Typically a sandy loam over a clay.
Throughflow	Water moving through the soil between the A and B horizons. Or, water passing through a swamp in a valley.
Topsoil	Surface layer of soil with higher organic content, A horizon.
Tor	Large outcrop of bedrock. In granite country tors are typically round boulders.
Trachyte	Fine grained igneous rock equivalent in composition to a syenite. Contains a small amount of free quartz.
Triassic	Period of geologic time 190-225 million years ago.
Tuff	Consolidated volcanic ash.
Turbidites	A suite of deep marine sedimentary rocks formed as a result of sediment transport by turbidity currents.
Ultrabasic rock	Igneous rocks containing less than 45% silica. Usually coarse grained and contain no free quartz or feldspar.
Unconformity	Surface between two rock units of different ages with different attitudes, represents an interval of time.
Uniform textured soils	Soils in which the topsoil and subsoil have very nearly the same textures.
Veins	Thin body of mineral such as quartz, intruded through a rock, usually following structural weaknesses such as joints.
Volcanic	Igneous rocks that have been formed on the Earth's surface as from a volcano.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